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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Steam Road Rollers & Tractors.

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement pages 24 and 25.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
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See half-page Advert. last week and next week. 1332

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See Advertisement last week, page 80.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page 78.* 1293
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1133

Cochran Boilers.
MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 1134

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported upon. Over 35 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

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PLANT AND MACHINERY
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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 617
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 67, June 22.

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PASSENGER AND CARGO STEAMERS,
SHALLOW DRAFT VESSELS. 818

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Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
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Chain.—SPECIFY WELDLESS STEEL.
The Strongest Chain in the World.
Sole Manufacturers: WELDLESS CHAINS, LTD., 50, Wellington Street, GLASGOW. 898

OIL FUEL APPLIANCES, *Systems*
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
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Naval Outfits a Speciality, also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od. 2487
See their Illus. Advertisement, page 55, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
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BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
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AUCTIONEERS, VALUERS AND SURVEYORS
for
ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 9886
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
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Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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CLUTHA WORKS, GLASGOW.
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OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
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Power and Speed of Vessels.
—Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1463, Offices of ENGINEERING.

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GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
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IRON & STEEL
Tubes AND Fittings AND Steel Plates.

STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 88. 1111

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 49, June 22.

Gearing for Power Transmission.
Including Machine Moulded GEAR WHEELS up to 10 feet dia.;
FLY WHEELS (rope or spur drive) up to 28 feet dia.;
IRON CASTINGS up to 15 tons each, in Loam, Dry or Green Sand;
ENGINES: "Uniflow," "Corliss" or Drop Valve.
BREAKDOWN Repairs a speciality.
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The Glasgow Railway Engineering Company,
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London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
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CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

One Responsible Engineer
REQUIRED in each works as Agent for our Course of Tuition in Automobile Engineering.
SOUTHERN ENGINEERING INSTITUTE, Newdigate, Surrey. A 752

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E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
306, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7434. Od 585

'Phone—Holb. 541. Tele.—Andrubo, Holb., London.
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Cement.—Maxted & Knott,
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Address, BURNETT AVENUE, HULL.
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For Your Repairs or any
SPECIAL MACHINERY, try—
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est. 1854. 1484

Carels Diesel & Steam Engines. 1120
CARELS DIESEL & STEAM ENGINES (LONDON), LTD., Carlton House, Regent Street, London, S.W. 1.
Telephone: Regent 3484.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROW'S PATENTS.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8723

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 819

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 1483
See Full Page Advt., page 50, June 22.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 57, June 22. 8195

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 1334
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

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THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
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D.B.S. GEARS
of every description.
1446
DAVID BROWN & SONS (Hudd.) LTD.,
Lockwood - - - - - Huddersfield.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 846

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 939
See half-page Advertisement, page 66, June 8.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

1923 L. No. 1325.

IN THE HIGH COURT OF JUSTICE,
CHANCERY DIVISION,
Mr. JUSTICE SARGANT.

IN THE MATTER OF THREE LETTERS PATENT, No. 1300 of 1907 and No. 19583 of 1907, granted to William Longworth and William John Stewart, for inventions entitled "Improvements in Hackling Machines for Flax and other like Fibres," bearing date respectively 28th August, 1907 and 2nd September, 1907, and No. 25766 of 1908 granted to William Longworth for an invention entitled "Improvements in Hackling Machines for Flax and other like Fibres," bearing date 6th November, 1908,
and
IN THE MATTER OF THE PATENTS AND DESIGNS ACTS, 1907 and 1919.

Notice is Hereby Given that

LONGWORTH & COMPANY, LIMITED, whose registered office is at Ormeau Road, Belfast, Assignee of the said Letters Patent, has, by originating Summons, dated the 16th day of May, 1923, applied that the terms of each of the above-mentioned Letters Patent may be extended and that the time within which the application may be made for the extension of the terms of the said Letters Patent Nos. 19300 of 1907 and 19583 of 1907 may be extended, and NOTICE IS HEREBY GIVEN that on Tuesday, the 31st day of July, 1923, application will be made to the Court that a day may be fixed before which the said Summons shall not be in the paper for hearing; and NOTICE IS HEREBY GIVEN that any person desirous of being heard in opposition to the said Originating Summons must, at least seven days before the said 31st day of July, 1923, lodge notice of such opposition at the chambers of Mr. Justice Sargant, Room No. 317, Royal Courts of Justice, Strand, London, and serve a copy thereof upon the applicants.
Dated this 25th day of June, 1923.
BRISTOWS COOKE & CARPMAEL,
1, Copthall Buildings, London, E.C. 2, Solicitors for the Applicants, on whom all documents requiring service may be served. A 945

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1401

TENDERS.

TO ELECTRICIANS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD
Invite

Tenders for the Installation of

ELECTRIC LIGHTING in the Kitchen Block and Nurses "A" Home at the Southern (Lower) Fever Hospital, Dartford, Kent, in accordance with drawings and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief.
The Drawings, Specification and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after Ten a.m., on Monday, 2nd July, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender, sent in accordance with the instructions on the Form of Tender, and after the Specification and the Drawings have been returned.
Tenders, addressed as noted on the form, must be delivered at the Office of the Board, not later than 2.30 p.m. on Wednesday, the 18th July, 1923.
(By Order) G. A. POWELL,
Clerk to the Board. A 940

COUNTY OF LONDON.

The London County Council invites

Quotations for the Purchase

and REMOVAL of the undermentioned MACHINERY, etc.:—
At ABBEY MILLS PUMPING STATION, ABBEY LANE, STRATFORD, E. 15. Two Horizontal Duplex Triple-Expansion Direct-Acting Pumping Engines, 14½ in., 23 in. and 33 in. cylinders and 36 in. rams, 4 ft. stroke. Three Lancashire Boilers, 30 ft. long by 8 ft. dia. Economiser of 120 tubes.
At NORTHERN OUTFALL WORKS, EAST HAM, E.6 (alongside BECKTON GASWORKS). Three Lancashire Boilers, 28 ft. long by 6 ft. dia. Two Vertical Tandem Compound Engines, 12 in. and 23½ in. cylinders, 14 in. stroke, each with 17 in. Centrifugal Pump.
Two Condensers, each about 7 ft. long by 3 ft. dia.
Four Gabbet's Mixers.
Three Wrought-Iron or Steel Tanks, viz.:—Two 34 ft. by 30 ft. 3 in. by 6 ft. 9 in. deep, and One 18 ft. by 14 ft. by 6 ft. deep.
A quantity of Cast and Wrought Scrap.
Forms for Quotations, Conditions of Sale and full particulars may be obtained on application to the Chief Engineer, at the Old County Hall, Spring Gardens, S.W. 1.
Quotations must be addressed to the Clerk of the Council, and must be delivered at the County Hall, Westminster Bridge, S.E. 1, not later than Four p.m. on Thursday, 12th July, 1923. No Quotation received after this time will be considered.
The Council does not bind itself to accept the highest or any Quotation.
JAMES BIRD,
Clerk of the London County Council. A 949

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, REQUIRES:—

Wheels and Axles, Disc

Type, 224 pairs.
Tenders due Two p.m. on the 17th July, 1923.
Tender forms obtainable from above. A 924

COUNTY BOROUGH OF BLACKBURN.

ELECTRICITY DEPARTMENT.

The Electricity Committee have

For Immediate Disposal and

REMOVAL the following STEAM and ELECTRICAL PLANT:—
1. Five Lancashire Boilers, by Yates and Thom, 33 ft. by 8 ft. 6 in., insured with M.S.U.A. for 185 lbs. working pressure, complete with Hopkinson fittings and McPhail superheaters.
2. Two Compound Boiler Feed Pumps, by J. P. Hall & Sons, size 8½ in. by 13½ in. by 8½ in. by 18 in. stroke, 5000 gallons per hour.
3. One Boiler-feed Pump, by G. & J. Weir, 8 in. by 10½ in. by 18 in., capacity 4500 gallons per hour.
4. Two Bellis-Siemens Steam-driven D.C. Generators, Engine 200 HP. compound, 115 lbs. pressure, 380 R.P.M. Dynamo, Bipolar, compound wound, double wound armature, will run in parallel or in series at 240 or 550 volts.
5. Two Bellis-Mavor and Coulson Steam-driven Sets. Engine 400 HP. 3-crank enclosed vertical tandem, compound type, 115 lbs. pressure, Dynamo Multipolar, compound wound type, Voltage 460/550. 256 Kw.
6. One Steam-driven Alternator, Engine by Willans, 3-crank compound type, 333 R.P.M. 115 lbs. pressure, Alternator by E.C.C. 1 phase, 50 cycles, 200 Kw.
7. One Bellis-Siemens D.C. 500 Kw. Set, 440-500 volts, 3-throw compound.
8. One 440 Kw. Motor Generator Set, by British Westinghouse; 470 B.HP., 500/550 volts one side, 440/460 volts other side.
9. One 300 B.HP. Motor, by Bruce Peebles, 1906 design, 440 volts, compound wound, Multipolar, D.C., speed 240/512 R.P.M., shunt regulator open type, 3 bearings, no pulley, slide rails and starting switch.

The Highest or any Tender will not necessarily be accepted.
The Corporation are open to consider Offers for the above Plant, and Tender Forms and particulars can be obtained from Mr. P. P. P. WHEELWRIGHT, Borough Electrical Engineer, Jubilee Street, Blackburn. A 961

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

300 HELICAL and 2000 VOLUTE SPRINGS, as per Specification to be seen at the Company's Offices.
Tenders addressed to the undersigned, and marked "Tender for Helical and Volute Springs," are to be lodged not later than Noon on Friday, the 20th day of July, 1923.
For each Specification a fee of 10s. will be charged which cannot, under any circumstances, be returned.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
H. A. NEVILLE,
Managing Director.
237, Gresham House, Old Broad Street,
London, E.C. 2.
21st June, 1923. A 910

TO BAKERY ENGINEERS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD
Invite

Tenders for the Installation of

a NEW BRICK TYPE STEAM PIPE PEEL OVEN at the South-Eastern Fever Hospital, Avonley Road, New Cross, S.E. 14, in accordance with drawings and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief.
The Drawings, Specification and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after Ten a.m. on Monday, 2nd July, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender, sent in accordance with the Instructions on the Form of Tender, and after the Specification and the Drawing have been returned.
Tenders, addressed as noted on the form, must be delivered at the Office of the Board, not later than 2.30 p.m., on Wednesday, 18th July, 1923.
(By Order) G. A. POWELL,
Clerk to the Board. A 939

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY of the following MATERIAL for the Morwell Power Scheme.
Copies of Tender Form and Specification, etc., will be available for inspection and purchase upon application to:—
THE AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.
SPECIFICATION No. 23/93—TRANSFORMERS.
CHARGE:—10s. for two copies of Tender Form, Specification, Contract, Conditions, etc., complete. This charge will be returned on receipt of a *bona fide* Tender.
A third or any further copies will be supplied for the sum of 3s. each, but this charge is not returnable.
PRELIMINARY DEPOSIT:—A preliminary deposit of £50 is required to be lodged with each Tender.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed forms, properly addressed and endorsed, must be delivered to the undersigned in Melbourne, not later than noon, 25th August, 1923.
R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. A 869

THE AGENCY FOR ANGOLA IN LONDON Invites, until 15th July next,

Tenders for Meters, Tubes,

PIPING, TAPS, etc., for the Water Supply of the Town of Loanda, Portuguese West Africa. Information will be given by this AGENCY, 76, Strand, W.C., any day from 9.30 to 5.30. A 947

COUNTY OF LONDON.

The London County Council invites

Tenders for the Manufacture,

SUPPLY, DELIVERY, etc., and MAINTENANCE of 200 SETS of TRAMCAR MOTORS, with accessories as specified, to complete the electrical equipment of bogie tramcars, and their assembly in readiness for service operation on bogie tramcars, which will stand for the purpose at one or more of the Council's car sheds or depots in London, as may be determined upon.
The Specification, Form of Tender, and other particulars may be obtained on application to the General Manager, London County Council Tramways, Victoria Embankment, W.C. 2, on or after Monday, 2nd July, 1923 upon payment of a fee of £2. This amount will be returnable only if a *bona fide* Tender is submitted and not withdrawn.
General particulars of the work may be obtained at the Tramway Offices, Victoria Embankment, before payment of the fee.
Any samples or drawings referred to in the Specification can be inspected by appointment with the General Manager, after payment of the fee referred to above.
Tenders must be addressed to the Clerk of the Council and delivered at the County Hall, Westminster Bridge, S.E. 1, not later than Four p.m. on Monday, 16th July, 1923. No Tender received after that time will be considered.
The Council does not bind itself to accept the lowest or any Tender.
JAMES BIRD,
Clerk of the London County Council. A 925

APPOINTMENTS OPEN.

UNIVERSITY OF LEEDS.

CHAIR OF MINING.

The Professorship of Mining

in the University will fall VACANT at the end of the present session upon the resignation of Professor GRANVILLE POOLE. A new appointment, taking effect on the 1st October, 1923, will be made in due course. The salary attached to this appointment will be £1000 a year. Further information may be obtained from THE REGISTRAR, The University, Leeds. Inquiries should reach him not later than the 9th July. A 919

UNIVERSITY OF LONDON: UNIVERSITY COLLEGE.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING.

The University College Committee will shortly

Appoint an Assistant

LECTURER in Theory of Structures and Structural Design.
Commencing salary £400.
Applications not later than 16th July, 1923.
Particulars may be obtained from the undersigned:—
WALTER W. SETON,
Secretary.
University College, London.
(Gower Street, W.C.) A 944

KENT EDUCATION COMMITTEE.

ERITH TECHNICAL INSTITUTE.
Erith Road, Belvedere.

There are Vacancies for Well

Qualified LECTURERS and INSTRUCTORS in the following subjects in the Senior Courses resuming in September next:—
Applied Mechanics and Heat Engines.
English Literature.
Gas Supply.
Fitting, Turning and Machinery.
Elementary Economics.
Salary in accordance with the Scale of the Kent Education Committee of which particulars may be obtained from the Secretary, Mr. A. T. FLUX, Education Offices, Belvedere.
Applicants should write at once to the Principal, stating qualifications and training experience, age, etc.
E. SALTER DAVIES,
Director of Education,
Maidstone. A 922

UNIVERSITY OF DURHAM.

ARMSTRONG COLLEGE,
NEWCASTLE-UPON-TYNE.

LECTURER IN MECHANICAL ENGINEERING.

The Council of Armstrong College invite

Applications for a Lectureship

as above. Salary £300 to £350, according to qualifications. University degree, or equivalent. Duties commence 1st October, 1923. Lecturer required to teach Mechanical Drawing, supervise work in Laboratories and undertake preparation of necessary drawings. Practical experience essential. Ten copies of application, and of not more than three testimonials, must reach the undersigned not later than 21st July, 1923.
J. Y. T. GREIG,
Registrar,
Armstrong College. A 957

Wanted, a Capable Man to

superintend Steam Engines and Electric Generating Plant, including Motor Drives. Constant work for suitable man. Apply by letter, giving full particulars of experience, age, references, etc., to G. N. HADEN & SONS, LTD., Engineers, Trowbridge. A 906

Wanted, at Once,

Temporary ENGINEERING ASSISTANTS with good experience in design of docks and heavy masonry, also assistant experienced in design of reinforced concrete wharves. Preference given to ex-Service men.—Apply, giving full particulars of experience, age, salary required, when disengaged, and enclosing copy of recent testimonials, to CIVIL ENGINEER-IN-CHIEF, Admiralty, S.W. 1. A 859

Wanted, Works Manager by

firm of Boiler Makers. None but first-class, up-to-date, and progressive men need apply.—Address, stating age, experience, in the first instance, A 923, Offices of ENGINEERING.

Wanted, Experienced

ESTIMATOR to calculate weights of Structural Steel and Gasworks Plant. Applications, stating age, experience and salary expected.—Address, A 913, Offices of ENGINEERING.

Power Station Superintendent

WANTED for a large Power Station in healthy part of the East. Four years' contract. Consideration will be given only to applications from men who have occupied responsible posts in similar capacity.—Address, with full details as to age, whether married or single, and full particulars of education and all subsequent experience, A 964, Offices of ENGINEERING.

TANK PILOTS.

A Limited Number of

VACANCIES for QUALIFIED MEN to be appointed to warrant rank exist in the Tank Corps of the Regular Army. Candidates must be in possession of either:—
(I) Associate Membership Examination of the Institution of Mechanical Engineers with its exemptions (to include Whitworth Prizemen).
(II) National Certificates (Higher) or National Diplomas (Higher) of Mechanical Engineering issued by the Institution of Mechanical Engineers in conjunction with the Board of Education (England and Wales).
(III) Diplomas of the Royal Technical College, Glasgow, or of the Heriot Watt College, Edinburgh.
Candidates must have also had a normal four years' manual apprenticeship.
Age limits 21 to 26 (30 in the case of men with previous service in His Majesty's Forces). Married men over 26 years of age are eligible. Pay £219 per annum and marriage allowance for married men who are accepted. Free food, clothes and lodging or allowances instead.
Candidates who are accepted will be enlisted in the Regular Army for a period of three years with the Colours and will be given immediate promotion to warrant rank.
Candidates, on completion of service, will, if desirous and recommended, be appointed to commissions in the Regular Army Reserve of Officers.
Applications, accompanied by qualifications, should be addressed to the COMMANDANT, Tank Corps Centre, Bovington Camp, Wool, Dorset. A 921

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In the case of these two grades, an allowance in respect of previous experience and war service will be granted up to ten increments of the scale. To be eligible for entry in Grade III, the candidate must be a Graduate or hold an equivalent qualification.
The courses of instruction include English and general studies, practical mathematics, mechanical drawing and engineering science. Preference will be given to candidates who possess qualifications in more than one of these subjects.
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The present scales of salary in the several grades are as follows:—
EDUCATION OFFICER GRADE I.
Scale of Pay ... ... £750 by £30 to £900.
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Scale of Pay £375 by £15 to £396 by £20 to £550.
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Scale of Pay ... ... £200 by £15 to £450.
Further particulars and the necessary form of application can be obtained from the SECRETARY, Air Ministry, Kingsway, London, W.C. 2. A 950

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Applicants must have served an apprenticeship in the sheds or shops of an English Railway, and have had subsequent experience as a Shed Fitter or Shed Chargeman on running repairs to engines, and in addition to simple machine shop practice and fitting work, should be able to straighten frames, try engines over for square, and set valves. Single men preferred. Age about 26 years.
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The selected candidates will only be appointed subject to their passing a strict medical examination by the Company's Consulting Physician.
Candidates must send in a full record of their general and technical education and training, giving details of the shops or departments worked in, and the class of work employed upon, with dates, together with COPIES ONLY of any testimonials, Service Certificates, etc., to the undersigned not later than the 13th July, 1923.
S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France,
Westminster, S.W.1.
26th June, 1923. A 951

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Quay.—REQUIRED for Rouen a thoroughly trained French MECHANICAL ENGINEER, with a good knowledge of electricity, to take charge of a quay near Rouen, consisting of rotary converters and electrical transporters working grabs. Must have had previous control of men and management of a wharf, and possess a knowledge of English. Salary not less than 1250 francs per month to commence. Reply, in English, giving age, whether married, exact account of previous experience and qualifications.—Address, A 918, Offices of ENGINEERING.

LITERATURE.

Plane and Geodetic Surveying for Engineers. Vol. I. *Plane Surveying.* Vol. II. *Higher Surveying.* By DAVID CLARK, B.Sc.(Lond.), Professor of Civil Engineering, University of Dublin. London: Constable and Co., Limited. [Price, Vol. I., 25*s.*, Vol. II., 25*s.* net.]

THE number of new treatises and new editions of works on surveying and earth measurement indicates that a very large audience needs instruction in this branch of engineering, and that teachers are dissatisfied with the existing handbooks. This fertility of publication is the more surprising, because there is little room for originality. Each author has to describe the same instruments, repeat the same operations, point out the sources of error, and emphasise the same need for precautions. The methods of treatment and arrangement may vary to some extent according to the object the author has in view, and the degree of accuracy on which he thinks it necessary to insist. The present textbook is designed to meet the needs of those who are working unaided in the field and of students in college classes under supervision. It differs from many earlier attempts in that it urges a high degree of accuracy of measurement, and contemplates the extension of methods to embrace cadastral, topographic and geodetical schemes of survey. It is a gratifying feature that recent treatises insist on the necessity for greater precision and exact a higher degree of accuracy. Instrument makers have responded to the demand, and while on the one hand, convenience of manipulation and delicacy of construction have supplied more efficient apparatus, the nicer appreciation of accuracy and greater care in the elimination, or compensation, of errors have been equally contributing factors in promoting the needed precision. The exactness now demanded requires that the error in fixing any point shall not be greater than the smallest amount that can be plotted on a map of the selected scale, while indicating all the accidents which distinguish the surface surveyed from a level featureless plane.

When the map is on a large scale this limit of accuracy is sufficiently rigorous, requiring not only a knowledge of methods, but of the instrumental errors whose effects may be removed by the application of corrections, either mechanical or arithmetical. Mr. Clark is fully alive to the important effects such errors exercise on the final result, and throughout he aims at attaining the greatest accuracy of which the instrument is capable. In describing the theodolite, for example, he is not only careful to consider the errors of eccentricity arising from the want of coincidence between the centres of graduation and of the motion of the alidade, but he would, we think, like to determine the errors of division of the circle itself. He admits, however, that this refinement might prove beyond the powers of the student and recommends reliance on the precision attained by modern dividing engines. This is, however, the first elementary book in which we have seen attention directed to the "runs" of the microscope. On the other hand, we find no reference to the need of caution in the illumination of the circle, a matter of greater importance, practically, for the graduations being cut lines, if the light falls from one side the illumination of the two edges of the graduation differs. On the subject of errors, it should be mentioned that wherever practicable the amount of error that may be expected in using different forms of apparatus is always indicated. Such information should be of great use to students working without other assistance than books afford, since it suggests a standard of accuracy to be realised in their work. These remarks are quoted to show that the work is of an eminently practical character, and on a much higher plane than the general elementary works on surveying.

The contents follow the usual order. An introductory chapter describes the purpose and adjustment of the instruments in most general use, and the succeeding chapters give instruction on the methods of measuring distances by chains and tapes, and of angles, by theodolites and compass. The description of the plane table and its adjuncts might have followed, but for some unexplained reason the author has preferred to sandwich this section between two chapters on levelling and contouring respectively, so closely connected that their separation appears injudicious. In this chapter on the plane table, a departure from the usual order is made by introducing the "three point problem" generally regarded as connected with hydrographic surveying, and indeed this same problem reappears again in that section. The author's discussion of the geometrical problem and his remarks on the peculiarities that arise in the practical application are quite adequate, but it may be noticed that in the solution no attempt is made to derive the probable error of location. This occasions no surprise, but the student might have been warned that the way in which the rate of decrease of the probability of position varies with the variation in direction cannot be covered by any simple statement. Two chapters of elementary importance follow on the measurement of areas and volumes, and on the setting out of works. The latter of these contains, of course, the application of the rules that have been given and the results that have been derived from the measurements supposed to have been made in the previous part. It is precisely the reverse of surveying as generally understood, inasmuch as the data shown on the plans are now transferred to the ground. It forms the beginning of a large subject, but the typical instances are worked out with thoroughness, and should prove instructive. Unfortunately, from the point of view of arrangement, the student is again led back to the subject of actual measurement of surveys by the introduction of the method of the tacheometer and the principle of the stadia rod. It may be permitted to express a doubt whether these processes are worth the trouble bestowed on them. Stadia work is seen at its best on rough ground where the conditions for chaining are at their worst, but at all times the reductions are involved and troublesome, and atmospheric refraction, increasing in effect, with the square of the distance measured, introduces an error which it is as difficult to estimate as it is to correct. Mr. Clark says that the error in distances from a single observation should not exceed 1 in 500, and that the closing error of a traverse should be less than $0{\cdot}10\ \sqrt{D}$ ft., where D is the length of the traverse in feet. Similarly, the error of elevation is put at about 0·3 ft. for moderate inclinations, and that the closing error of elevation in circuits between bench marks should be less than $0{\cdot}01\ \sqrt{D}$ ft.

The last chapter of the first volume is devoted to hydrographic surveying, a brief outline being given of the simpler phenomena observed in tidal motion. This outline follows the usual conventions and the author may claim that he has given a correct representation of what would occur on an ideal globe, entirely covered with a frictionless ocean. But even if the description be correct, it does not exhibit the conditions with which we are acquainted, for the ideal tide imagined does not remotely apply to the actual tides to which our oceans are subject. The discussion of the tidal phenomena at a single port is more satisfactory, and when the author escapes from the meshes of an unsatisfactory theory and describes the processes involved in measurement, wherein alone the engineer is concerned, his work is instructive and convincing.

Volume II. Higher Surveying. The author does not claim that a knowledge of geodesy is essential to an engineer, though he may be called upon to undertake measurements calling for the same degree of accuracy that characterises geodetic surveying and levelling, and in which the spherical figure of the Earth cannot be neglected. He urges therefore that the student should acquire a sound grasp of the principles underlying the measurement of large areas on a spherical surface, and be competent to construct a framework of reference which will oblige him to make use of astronomical data. As a fitting preparation, the first chapter supplies the necessary definitions and elementary problems, and we are glad to note that the accuracy exhibited is all that can be desired. The irritation caused by inaccurate description, so common in elementary works, is not experienced here, but it may be suggested, that some of the refinements mentioned are unnecessary. In first-class triangulation, no possible source of error will pass unregarded, the scrutiny may be even more scrupulous than is suggested, but such work is entrusted to skilled observers, who have been trained and disciplined as specialists. As a matter of history much of the matter is informing and not willingly to be dispensed with, but it is submitted with deference, that it is not desirable to attempt to give to a large class that special information which can be of practical use to only a few. Some of the processes described are obsolete, such as the determination of longitude by lunar distances, while the introduction of wireless signals will supersede some of the other methods mentioned. Among latitude determinations pride of place is rightly given to the Horrebow-Talcott method, but some of the other methods described might have been omitted as not possessing the necessary accuracy. It is, however, most important that the student should be aware that he is not limited to a single process, that he can check his work by the use of a variety of methods, and learn how to use his instrumental equipment to the best possible advantage.

It may seem ungracious not to welcome discussion on such nice points as the theory of the catenary applied to tape measurements, or of the effect of changes wrought by gravity in the length of a tape when used in a different latitude from that in which it has been standardised, or at a different elevation above the Earth's surface. But such refinements, as a matter of practice, only concern those who attempt measurements of distance, within an error of a millionth of that measured, and such achievements are rare. On the other hand, it is the work of a large class to get the best results possible from the measures, though they are made by instruments that will not show seconds of arc nor hundredths of millimetres. The chapter on survey adjustments, founded on the conventional theory of errors, should be generally read, for it conveys a useful lesson. The portion dealing with conditioned quantities, in which certain geometrical relationships have to be fulfilled might have been extended, though some may think that we are pleading for an unnecessary degree of accuracy. Such discussion, however, is not useless if it convinces the observer of the magnitude and the character of his errors of observation. Obviously, it is difficult to compile a treatise that shall lead the tyro through the difficulties of a chain measurement, and also serve as a work of reference to the expert who cannot satisfy himself with the degree of accuracy he has attained after adopting all precautions. Professor Clark has endeavoured to cater for both classes, or rather for all, in their various stages of advancement, and we hope that the success of his book will be proportionate to the care he has bestowed upon its preparation.

The Modern Ironfoundry. By JOSEPH G. HORNER, A.M.I.Mech.E. London: Henry Frowde and Hodder and Stoughton. [Price 15*s.* net.]

THERE is always a danger with the growth of specialisation in industry that the apprentices and also the younger workmen generally, will only obtain a smattering of knowledge of their trades, and as they may be kept on the same class of work for long periods, they may not have the opportunity of acquiring an adequate experience. In places where specialisation has been carried to extremes the trouble has been very pronounced and few true craftsmen can be found. America, through these causes has now an industrial population composed almost entirely of repetition workers. Cheapness in production of individual articles may be attained, but at the expense of the loss of craftsmanship and thorough knowledge, without which progress in many fields of activity is impossible. Although conditions in the industrial works of this country are not so extreme, there is a danger of producing inferior workmen, and Mr. Joseph G. Horner has foreseen this as a possibility in foundry work. To help the earnest young worker to help himself, Mr. Horner has written this book on "The Modern Ironfoundry." It was written from the standpoint of the actual workshop and fulfils the intentions of the author in quite an admirable way. It will be of incalculable value to those young fellows who are in earnest in their determination to obtain a thorough and comprehensive knowledge of all matters relating to ironfoundry work.

The properties of iron vary with the composition

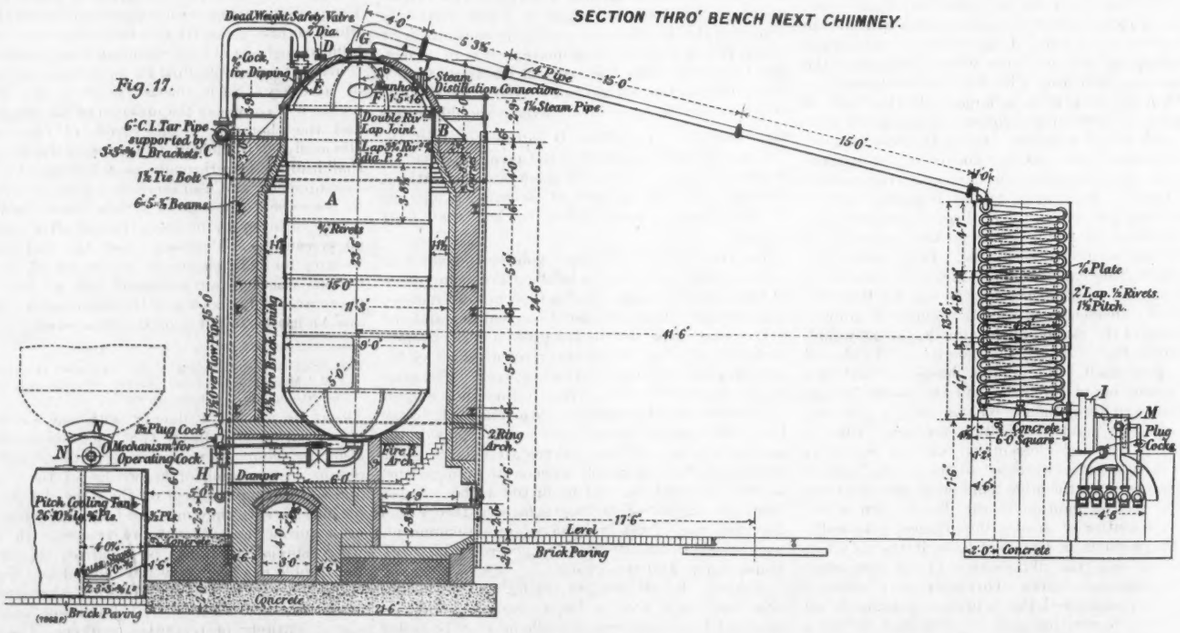
of the ores and scrap used in its production. In an interesting opening chapter the author deals with this subject and the testing of the metal. Following on this are chapters on the construction and working of cupolas, the auxiliary appliances used in moulding and on fuels and sands. These preliminary chapters are of great importance to the young ironfounder, for in them he will find reasoned statements for many things he may have previously taken on trust without giving the matter much thought. Methods of moulding with special chapters on flywheels, cylinders, the use of the former in ironfounding, machine moulding, permanent moulds and die casting, are given full consideration and described in relationship to specific examples of actual work. Other matters dealt with are faults and the means taken to prevent their occurrence, runners and risers, while the book is concluded with a consideration of the design and equipment of a general foundry which will provide accommodation for the work of 80 to 100 hands. The author has worked out a design of workshop suitable for light, medium and heavy casting in green and dry sands and loam. While it is in no sense a specialised foundry, there has been no neglect of labour-saving methods in dealing with its arrangement and equipment.

The book is well written, amply and clearly illustrated, and will be a valued addition to the library of any young engineer or foundryman.

THE PROVAN CHEMICAL WORKS OF THE GLASGOW CORPORATION.

(*Concluded from page* 764.)

THE processes of tar distillation are twofold, firstly the crude distillation, and secondly the operations of separating and refining the products.



The primary operation is performed in closed stills for the liberation and condensation of the volatile matter and leaves pitch as the residual. This operation is carried out at all the four gas works in Glasgow. Two types of tar still are in use. The first is simply an egg-ended boiler (see Fig. 17) of 23 ft. 6 in. overall length and 9 ft. diameter. The still is supported on its brickwork setting by six gusset stay brackets B riveted to the still near the top. The charging main C is brought to a point on the curved top near which is a safety valve. Other mountings on the top are a manhole and the vapour outlet. The pitch run-off pipe is fitted with a steam jacketed gland cock. This outlet pipe is effectively protected from the heat by brickwork. The furnace, ash pit and duct to convey the gases to the chimney are all clearly shown in the illustration. After liberation the volatile matter is conducted by a pipe to the coil in the condenser tank where much of its heat is removed and the liquid produced is passed to the dividing box M for separation into fractions.

A great source of trouble in connection with the distillation of tar is the presence in the crude material of a certain amount of ammonia water. Firing must be performed very carefully until this has been completely driven off, otherwise frothing actions occur accompanied by the carrying over of tar into the condensing plant. To speed up the distillation process and at the same time prevent frothing troubles, preheaters have been introduced for the purpose of performing a preliminary dehydration. The heat necessary for the operation is obtained from the vapours coming away from the tar stills. An installation of such plant has been erected in the Provan Works and details are shown in Figs. 18 and 19, Plate XLVII. The equipment consists of four stills, four preheaters and six condensers, and is capable of dealing with 200 tons of tar per day. In the plan, Fig. 19, only one-half of the plant is shown, the other half being exactly similar. The tar stills are erected by the side of a raised platform which accommodates the preheaters and condensers. All the condensates are delivered into dividing boxes communicating with pipes to carry away ammoniacal liquors, naphtha, light oils, heavy oils and creosote.

The tar still is a simple cylindrical vessel, 11 ft. diameter, having a domed top and a dished bottom. It is made of steel plate, the side joints being riveted while that in the dome is welded. The bottom plate is in one piece so that joints do not interfere with cleaning operations. The inlet pipe and the vapour outlet project into the dome to prevent the corrosion which would take place if the condensation in the pipes could not drop back into the tar. The top of the upright outlet pipe is carried into the spherical top to form a lip which will catch any condensation at this point and convey the liquid into the condenser pipes. The furnace and still seating are shown in Fig. 18. There are pigeon holes through the seating to permit the passage of the hot gases to the outer flues surmounting the still. At the points where the gases pass under the still fire tiles are introduced to protect the bottom. By removing the bricks surrounding the still at the top of the cylindrical part the complete still may be lifted out of place and a new one dropped into position. The amount of work necessary in replacement is thus cut down to a minimum. The vapours from the still are passed through two D-shaped coils in the preheaters. These are lap-welded 3-in. pipes which provide a heating surface of about 240 sq. ft. Their form is shown in the drawings of the plant. In these coils some of the heat of the vapours is given up and liberates the ammoniacal water from the tar in the preheater. When the distillation of the tar in the still is completed all the water which was contained in the crude material in the preheaters has been driven off. After the pitch left in the still has been run off into the coolers and prior to being run on to the pitch beds, the crude tar from the preheaters is fed into the still as its next charge. Working on this sytem it is possible to accelerate the operations considerably, as the tar is already dehydrated before it reaches the stills, and no disastrous effects ensue if the firing is rapid. When it is stated that it takes about 28 hours for the complete distillation of a change in the simple still first described and only 6 hours in the second case, the value of preheating is evident. The gases pass on from the preheater coils to those in the condensers, which are also arranged in D-shape, but are of 2-in. diameter and provide a cooling surface of 200 sq. ft.

The plant shown in Figs. 20 and 21, Plate XLVIII, is used at the Provan Works for naphtha stripping, but similar plants are in operation in another of the works for tar dehydration. Some interesting experiments have been conducted by Mr. Walmsley with two of these Wilton plants and a steaming still to obtain continuous tar distillation. The complete plant is shown in the illustrations and consists of a furnace suitable for burning coke breeze, the gases from which pass up a central flue and then down by the outer one, over a coil of 3 in. cast iron pipes. When used for tar dehydration and distillation the crude tar is passed directly into the heated pipe coil and leaves at the top at about 170 deg. C. to 180 deg. C. and 30 lb. to 40 lb. pressure where it enters an open box in place of the vapour chamber used in naphtha stripping, which will be described later. The residual dehydrated tar from the open box is passed on to a second "Wilton" coil which is maintained at a much higher temperature but at a lower pressure than the first one. Successful results have been obtained in continuous tar distillation with this arrangement. A steaming still kept hot by the waste furnace gases from the first coil was used in the early experiments in treating the residual tar with superheated steam, but this was found to be unnecessary, as a good medium soft pitch could be obtained without its use. The complete plant arrangement in Figs. 20 and 21, is that adopted for treating oils for naphtha stripping which will be referred to later in this article.

The third section of the works was designed to treat the tar oils for the production of tar acids,

the stripping of naphtha from the light oils and the extraction of benzol.

The oil washers used are of the Typhoon type and their construction is shown in Figs. 22 and 23, Plate XLVIII. They are built of rolled steel plate and fitted with a conical base plate. When a charge of oil and caustic soda solution has been introduced the belt striker gear is pulled over and the motion is carried through the bevel gears to the paddle, A, which is run at 95 r.p.m. A vortex is formed in the centre of the liquid, and the three radial baffles, B, are lowered to just break the surface of the fluid, and make some of it run into the centre of the vortex. After the agitation has been completed the contents of the washer are allowed to settle. The sodium salts of the tar acids are later run off from the foot of the plant, and pumped into carbonators consisting of old tar stills where carbon-dioxide obtained from the waste gases from the sulphate of ammonia plant is bubbled through the material to liberate the tar acids and form sodium carbonate.

The causticising plant was designed to give a yield of up to 20,000 gallons of crude tar acids per week. It is of the Dorr type, and capable of producing 10 tons of caustic soda per day. The lime and soda ash are brought into the works by railway wagons and are elevated by an electric hoist into a raised store. They are first slaked in a Harding conical ball mill from which the material flows into a sump and is pumped from there to the first reaction agitator, then to the second, and on to the thickener. From the top of the Dorr thickener, caustic soda overflows and the calcium carbonate sludge is pumped to the next thickener where it meets with wash water as it leaves the pump. The overflowing weak alkali goes back into the process while the calcium carbonate is recovered with an Oliver filter.

The reaction agitator is illustrated in Fig. 24. The lower part of the shaft is hollow, and a small tubular nozzle for compressed air is introduced into

Fig. 24.

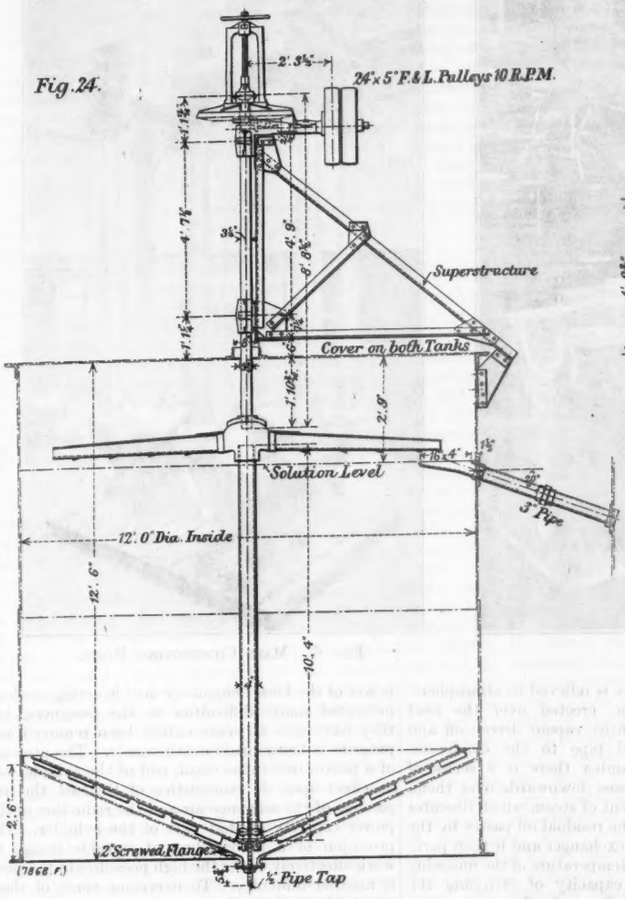


Fig. 25.

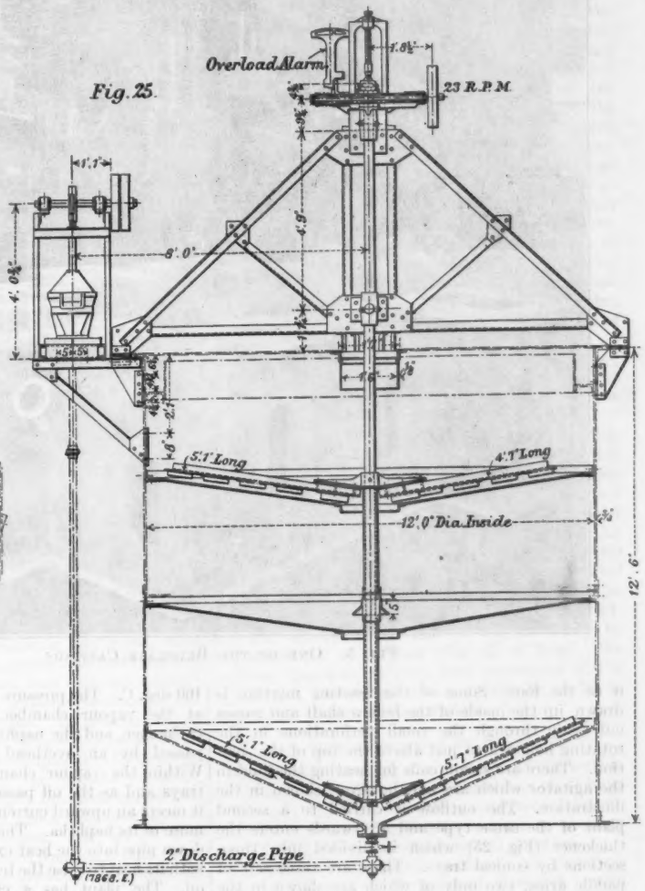


Fig. 26.

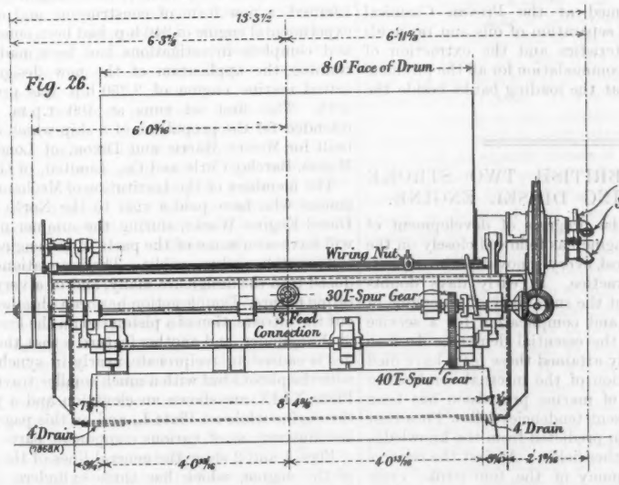
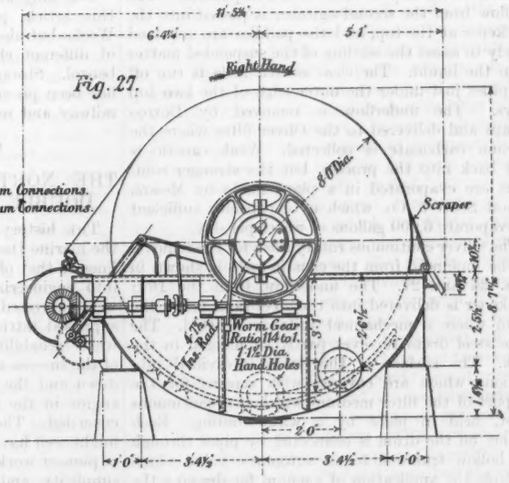


Fig. 27.



DETAILS OF TWO-STROKE DOUBLE-ACTING DIESEL ENGINE.

CONSTRUCTED BY THE NORTH BRITISH DIESEL ENGINE COMPANY, LIMITED, GLASGOW.

FIG. 5. ONE OF THE BEDPLATE CASTINGS.

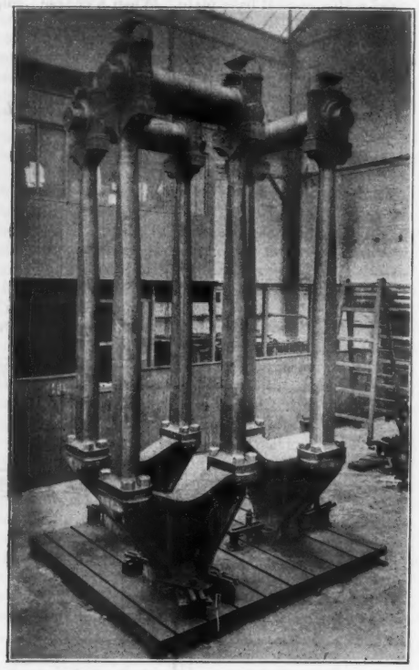


FIG. 6. MAIN CONNECTING RODS.

it at the foot. Some of the reacting mixture is drawn up the inside of the hollow shaft and passes out again through the small perforations in the rotating hollow arm just above the top of the solution. There are steam coils for heating the fluid in the agitator which are not, however, shown in the illustration. The outflow is carried to a second plant of the same type and afterwards enters the thickener (Fig. 25) which is divided into three sections by conical trays. There are three sets of paddle arms, two only of which are shown in the illustration but the middle one has the same relative position to its tray as those drawn in position. The outflow from the second agitator is passed into the thickener at the top, and the paddles are revolved slowly to assist the settling of the suspended matter from the liquid. The clear caustic soda is run off by pipes just under the outer edge of the two top trays. The underflow is removed by Dorrco pumps and delivered to the Oliver filter where the calcium carbonate is collected. Weak caustic is sent back into the process, but the stronger solutions are evaporated in a plant made by Messrs. Ernest Scott & Co. which is of capacity sufficient to evaporate 6,000 gallons of water per day.

The Oliver continuous rotary filter for the removal of the lime mud from the caustic soda is shown in Figs. 26 and 27. The underflow from the Dorr thickener is delivered into the steel tank below the drum where a mechanical agitator is fitted. The large steel drum revolves partly submerged in the tank. The surface of the drum is divided into sections which are covered with screens for the support of the filter medium which is a continuous sheet, held in place by a wire winding. Each section on the drum is connected by pipes through the hollow trunnion to an automatic valve which controls the application of vacuum for drawing the material through the filter and, at the necessary time, the application of steam or air to loosen the cake. As the drum is revolved the cake is scraped off from the face of the drum.

The naphtha stripping plant has been referred to in this article in its use as a tar dehydrator and still. Figs. 20 and 21, Plate XLVIII, show the complete plant. The oil is forced through cylindrical heat exchangers to the Wilton coil which it leaves at a pressure of 30 lb. to 40 lb. and at a temperature of 160 deg. C. The pressure is relieved to atmospheric at the vapour chamber, erected over the heat exchanger, and the naphtha vapour driven off and passed by an overhead pipe to the condenser. Within the vapour chamber there is a series of trays and as the oil passes downwards over them, it meets an upward current of steam which liberates more of its naphtha. The residual oil passes by the down pipe into the heat exchanger and it then parts with its heat to raise the temperature of the incoming oil. The plant has a capacity of stripping the napthha from 10,000 gallons of oil per day.

Not only are the main processes referred to in this article performed at the Provan Chemical Works but also the separation of oils and tar acids of different characteristics and the extraction of benzol. Storage accommodation for all the products has been provided at the loading banks beside the railway and roads.

THE NORTH BRITISH TWO-STROKE DOUBLE-ACTING DIESEL ENGINE.

THE history of the progress of development of the marine Diesel engine has followed closely on the lines of that of almost every innovation introduced into engineering practice. In early days doubts were expressed about the suitability of an engine of supposed intricacy and complication for a service where reliability is the essential demand. In face of the success already attained those fears have died down and the position of the internal combustion engine in the field of marine propulsion has been conceded. The present tendencies follow lines that might well have been predicted from the knowledge of pioneer work in other fields. At first the relative simplicity and economy of the four-stroke cycle engine attracted attention and great progress has been made in the installation of single-acting engines working on that system. When the two-stroke cycle engine had been so much improved in design to obtain increased reliability and reduced fuel consumption, it took its place in the general lines of development. The attractiveness of an increased power production from a given-sized cylinder proved great and many of the early difficulties were soon overcome. To obtain a further increase in the power of the Diesel engine by double-acting working presented many difficulties to the designers, but they have now to some extent been removed and progress is being made continuously. The presence of a piston rod in the crank end of the cylinder has an effect upon the combustion of the fuel, the free passage of the scavenge air and the reduction of the power capacity of that part of the cylinder. The provision of a stuffing-box of suitable design to work effectively under the high pressures of the gases is another difficulty. To overcome some of these effects Mr. J. C. M. Maclagan has introduced, jointly with the North British Diesel Engine Works, Limited, a new form of construction and after an experimental engine of 240 h.p. had been constructed and complete investigations had been made of its running, the application of the new design to an actual marine engine of 2,250 h.p. was proceeded with. This first set runs at 100 r.p.m. and is intended for the propulsion of a ship which is being built for Messrs. Harris and Dixon, of London, by Messrs. Barclay Curle and Co., Limited, of Glasgow.

The members of the Institution of Mechanical Engineers who have paid a visit to the North British Diesel Engine Works, during the summer meeting, will have seen some of the parts of the engine under construction and assembly. The innovations introduced into the design are many, and of a very interesting nature. Double action has been obtained without the introduction of a piston rod on the lower part of the cylinder, and another feature is that the cylinder is caused to reciprocate nearly in synchronism with the pistons but with a much smaller travel. On Plate XLIX are shown an elevation and a plan of the engine while on Plate L, and on this page, there are illustrations of various component parts.

Figs. 1 and 2 show the general lines of the design of the engine, which has three cylinders, 24½ in. diameter, while the piston stroke is 44 in., and that of the cylinder liners is 13 in. A three-stage air compressor is driven from an extension of the main crankshaft at the forward end and a double-acting scavenge pump is provided at the other end. The whole structure is supported by side columns of box section, which are shown in Fig. 3 in the process of machining. These columns are erected upon a cast bedplate, one of the two parts of which is illustrated in Fig. 5. Being cast with a solid flat

underside no special seating is required for the bedplate, and it provides a receptacle for the lubrication oil. The engine has open-ended cylinders which, with their water jackets and the scavenge and exhaust branches, are free to reciprocate relatively to two fixed cylinder covers provided at the top and bottom. These covers take the form of stationary pistons with gastight rings and their construction is illustrated in Fig. 4, where two of them are shown alongside one of the cylinder liners. The top cover for each cylinder is carried on a bridge structure connecting the tops of the two side columns and a somewhat similar construction connects brackets on the lower parts of the frame to give support to the bottom cylinder cover. On each front column there is a water-cooled guide plate for the main guide slipper. A heavy gudgeon pin passes through the piston and projects on either side to give its motion to the ends of the forked connecting rod (see Fig. 6). At the foot of the connecting rod there is provided a heavy bearing which works on the crank pin. The motion for the cylinder liners is taken from the main crosshead pins by the use of rocking levers. The cylinder consists of two separate parts, one for each end, and they are joined by tie rods in such a way that a space is left between them of sufficient size to permit the motion of the crosshead pin. Constructing the cylinders in this way facilitates the inspection and cleaning of the rings of the piston and the covers, as the only operation necessary is the removal of the ties.

The oil inlets are arranged within the recessed cylinder covers. The ordinary camshaft construction for the operation of the fuel valves is dispensed with, the requisite motion for the valves being taken from the sliding cylinders. Starting air is admitted through an annular space surrounding the oil jet system. Scavenge ports are cut through the liners at the one end, and exhaust ports are located so as to be uncovered by the piston when both piston and cylinder liner are near the ends of their strokes. Both sets of ports extend round the complete circumference of the cylinder. When the piston is at the end of its stroke the exhaust ports are uncovered by it, while the scavenge ports are opened by the motion of the liners past the top cover. To enable the scavenge ports to be open for a certain time after the exhaust ports are closed, the motion of the sliding cylinder is given a lag behind that of the piston which amounts to about 15 deg.

The operations may be followed by considering the top end of the cylinder when the piston is at the bottom of the stroke the scavenge and exhaust ports are open, and as the piston moves upwards the exhaust ports are closed first and then the scavenge ones. When the compression of the air is completed the fuel oil is projected into the cylinder and both piston and cylinder move downwards, continuing their travels to the ends of their strokes when the exhaust and scavenge ports are again uncovered. Similar operations, of course, take place at the other end of the cylinder at the same time.

The exhaust from each end of the cylinder is brought to a common exhaust pipe, a part of which moves inside the end of a branch connection from the exhaust manifold. These branch connections pass through the back columns of the engine. Water cooling is applied to the entire exhaust pipe arrangements. The front box columns constitute the air receivers for scavenging and have stuffing-boxes fitted at the top, and near the middle for the sliding scavenge branches. The water pipes for piston cooling are attached directly to the centre of the length and thus are short, and their arrangement is simple. All the fuel pumping and engine control gear is mounted at the forward end of the engine. The control is by a single lever, and air may be admitted on starting to both ends of all cylinders, followed by the admission of fuel to one end of each cylinder prior to throwing over the lever to full fuel running.

The construction gives a combustion space of good shape for efficient working and effective water jacketing. The centre of the crosshead guides being in the same horizontal plane as the centre of the piston, the rubbing actions of the piston on the cylinder walls, it may be anticipated, will be small. Through the piston and cylinders having relative motion the actual piston speed is much smaller than in a fixed cylinder engine. This reduction, it is anticipated, will have the effect of giving a diminished rate of wear of cylinder liner and piston rings. Another effect of the moving cylinder construction is shown in the reduction in total height for a specified power.

This interesting attempt to obtain the advantages of double-acting working, with the elimination or reduction of the disadvantages inherent in the system when a piston rod passes through the crank end of the cylinder, must be regarded as a step towards the ultimate goal of all internal-combustion engine designers, the production of a reliable and economical engine of small weight. The results obtained in the tests when the engine is completed, and information on its running when installed in the vessel, will be looked for with great interest by the engineering world.

THE INTERNATIONAL AIR CONGRESS.

THE International Air Congress, the objects and scope of which were briefly explained in our issue of the 15th inst., on page 753, was duly inaugurated on Monday, the 25th inst., and has been continued throughout the week. The opening of the Congress was performed by H.R.H. the Prince of Wales who, after welcoming the delegates, said the day must be regarded as a red-letter one since the present was the first occasion on which an International Air Congress had been held in London, although, in the Royal Aeronautical Society, Great Britain had what, he believed, was the oldest aeronautical body in the world. Persons now living had been able to witness the achievement of what had long been man's ambition, viz., mechanical flight. Many great men in history, such as Roger Bacon and Leonardo da Vinci, had inquired into the problem of flight, but it had remained for us to see it solved. All present, His Royal Highness continued, were aware of the uses to which aeronautics had been put in war and though he hoped that experience would never be repeated, it had certainly resulted in the very rapid growth of aviation. In consequence of this we were able to perceive the great possibilities of the air in peace, and the development of these possibilities was the object of the present Congress. There was no more essentially international science than that of aeronautics by which such great speeds of locomotion were attained, and which was independent of the accustomed frontiers; both these factors tended to foster the growth of international peace. His Highness then declared the Congress open.

The inaugural address was then delivered by His Grace the Duke of Sutherland, who is chairman of the Main Committee of the Congress. His Grace remarked that it had been truly said that the present time was one which was pregnant with great possibilities for the future. It was believed that, within the next decade or two, aviation would bring about a partial or complete readjustment of our mode of living both as regards means of transportation and with respect to our present calculations of time and distance. He believed that the state of mankind would be bettered and their general prosperity improved by these advances. Modern aviation, he continued, had reached its present state in the space of fifteen years, and he believed that, with proper support, equally great, or even greater, developments would be made in the near future. Civil aviation would be a potent factor in promoting good feelings between nations as well as being of immense commercial advantage. It was to assist in bringing about this great purpose that the labours of the Congress would be devoted, but the results of these and of other labours must be properly applied by the continued support of Governments, as well as by the business initiative and patriotism of private citizens and wealthy and influential companies. After brief references to the possibilities of the light aeroplane and to the work of the previous international air congresses, His Grace expressed the hope that a regular series of similar congresses would be held in the future, adding that frank and free discussion of ideas between workers of all nations was the best method of furthering progress. Finally he expressed thanks to H.R.H. the Prince of Wales for having opened the Congress and to the Institution of Civil Engineers for having granted the use of their building for the purposes of the meetings.

Dr. W. H. Maw, the president of the Institution of Civil Engineers, in responding on behalf of the Institution, remarked that in the last few years the chief nations of the world had made energetic efforts in connection with the conquest of the air. These efforts had given rise to a number of new problems, many of them very important and the majority of them of special interest to engineers. It was thus very fitting that the present important gathering should be held at the Institution of Civil Engineers, and he assured the members of the Congress that the council and members of the Institution regarded it not only as a great pleasure, but also as a great privilege to act as their hosts. He recalled the fact that in the past engineers had taken a most important part in the practical development of aviation and he was convinced that they would give similar, and possibly even more effective, aid in the future. Success in aviation could only be attained by continued researches of the most varied and far-reaching character, while the practical utilisation of the facts revealed by such researches would make very heavy demands upon our stores of engineering knowledge and experience. Finally, on behalf of the Council and Members of the Institution, he extended a hearty welcome to His Grace the Duke of Sutherland and his colleagues of the International Air Congress.

At the conclusion of the inaugural proceedings the Congress divided into four groups for the reading and discussion of papers. The subjects dealt with by Group A were aerodynamics, construction and research, &c., while Group B was devoted to power plants, fuels, lubrication, air-screws, &c. Air transport and navigation matters were dealt with in Group C, while the remaining Group D, attended to the military aspects of aviation and airships. Altogether about 60 papers, were presented for reading and discussion, so that it will obviously be impossible for us to deal with all of them. We propose, therefore, to give brief summaries of the papers and discussions which appear to us to be most likely to interest our readers.

STANDARDISATION IN RESEARCH.

On Monday morning, the attention of one section of Group A, under the chairmanship of Colonel O'Gorman, was devoted to the questions of standardisation in research methods, systems of showing aerofoil shapes and in mathematical notation.

Sir Richard Glazebrook prefaced his paper on "Standardisation of Methods of Research" with some references to the significance of standardisation and its necessity in the production of machine parts and in the tests of the materials used in the construction of aeroplanes, as well as in the apparatus and the methods of their application in investigation work. Standardisation in design was harmful to progress, but was essential when mass production had to be introduced to manufacture in large quantities in times of emergency. It was an undoubted fact that much of the progress of aeronautics was due to research work, both on full-scale machines and in model experiments carried out in wind tunnels. Owing to the great variations in the design of the channels in which the greater part of the research was done, it was not possible to make exact comparisons between the results obtained by the various workers. The investigator can never be sure that the scale effects introduced into the determination of full-sized conditions from model experiments remain constant throughout all the conditions of actual working. There was an acknowledged difference between the conditions of running of an aeroplane in free air and of a model suspended in an air flow which was straightened out and confined by the walls of a tunnel. With various forms of channel differing relationships of the results were to be anticipated. Sir Richard described the shape and construction of many of the wind tunnels, such as that at the National Physical Laboratory, the Eiffel type, that of the Royal Aircraft Establishment, the Göttingen plant, and the American installation at Langley Field. The balances or measuring instruments also varied in construction very widely, and, in consequence, the difficulties of making comparisons of results were increased.

Air Commodore Brooke Popham, when Director

of Research, wrote to the Advisory Committee on Aeronautics, suggesting the desirability for comparative tests with exactly similar models in the representative wind channels of Britain, France and America. When the Aeronautical Research Committee was formed the proposals received approval and a scheme of tests was drawn up. The co-operation of the aeronautical authorities of other countries was obtained and the scheme was started. Two models were constructed and made available for test work in the wind tunnels of those countries, which were invited to join in the proposed co-operation, as well as others, who applied to be permitted to join in the scheme. The aerofoils were first tested out at the R.A.E. and a report was drawn up and presented to the Aeronautical Research Committee in May, 1922. The investigations in the French wind channel were then conducted and completed by November, 1922. The scheme has worked out most satisfactorily, but the authorities have decided to refrain from publication and general discussion of the results so far obtained until all are available.

Sir Richard concluded his paper with a statement of the opportunities for research in Britain and the methods of procedure at the National Physical Laboratory and at the Royal Aircraft Establishment. Nearly all of the work done at the National Physical Laboratory was concerned with general problems, such as lateral stability, the determination of rotary coefficients, effects of air flow round the body of a machine as affecting the air screw performance, determinations of equivalent free air speeds, control at low speeds, wings of high lift, the effects of modifications such as the Handley-Page slot and the application of Prandtl's theory of lift and drift and the corrections it involves in model experiments. At the Royal Aircraft Establishment work of an entirely different character was performed, and largely with full-scale appliances, developed for their special purposes. Examples cited were the recording control stick, gyroscopes for measuring the rate of responses of the controls and accelerometers which register at each movement the acceleration of any part of the machine to which they were applied.

Theoretical work was not neglected, as was evident from the work of Glauert in advancing the work of Prandtl, Bairstow on the application of the theory of a viscous fluid to aeronautics, Pippard and Southwell on stresses and strains, and of Pannell, who was lost with the ill-fated R 38, on the pressures to which an airship is subject.

At the conclusion of Sir Richard Glazebrook's paper the Chairman announced that it was proposed to take the other papers on standardisation of the method of computing wing sections and on mathematical notation before the discussions.

Mr. A. G. von Baumhauer then read his paper on a "Proposal for Standardisation of the Methods of Computing Wing Sections." The aims underlying the proposals, which were presented as a report of the Ryks-Studiedienst Voor de Luchtvaart, were that exact definition and a good general impression of the form were given. Before detailing the method proposed, the schemes adopted by the research workers of Britain, France, America and Germany were described and criticised. The standard proposal submitted consisted of giving an outline form without any dimensions whatever, but with vertical and horizontal axes shown, and the dimensions of the ordinates and abscissae given in a separate table. The horizontal axis was defined by two or more points of contact with the lower surface or, alternatively, the line on which the maximum length was intersected. No claim of originality was made for the method, but it was put forward as a suggestion for general adoption.

The third paper was on the subject of standardising the mathematical notation of aeronautics and was presented by Commandant du Genie E. Herrera. The question of unifying practice in the use of symbols in all the countries of the world has been frequently discussed, formerly without the attainment of much practical result. The proposed scheme submitted for consideration as a standard took account of the requirements in groups, namely, algebra, geometry, mechanics, aerology, aerodynamics, aeronautics, physics, chemistry, construction, thermodynamics, geography and astronomy, and economics. An exhaustive scheme was submitted, in which Roman, Greek and other symbols were employed.

In the discussion of Sir Richard Glazebrook's paper Mr. von Baumhauer emphasised the necessity for a standard method of computing the form of a propeller. He contended that sending the same aerofoils to each national wind channel meant a great waste of time, which could be avoided if exact definition on a standard form were possible. Major A. R. Low contended that standardisation of research was a contradiction in terms, although he agreed with the necessity for the suggestions of the author of the paper. The effects of the supports of the models were very marked. Now that the circulation theory of lifting actions was taken up officially, he thought it was necessary to give suitable acknowledgment to the work of Lanchester. After referring to the efforts of Lord Kelvin and Professors Tait and Clerk Maxwell to get a rational system of units for electrical work, he asked what had been done in connection with aeronautics. He regretted the great amount of time which had to be taken up in transforming the units of other people's work to put them into line with British practice to effect comparisons of the results. Colonel C. L'Estrange Malone put forward a plea for a greater expenditure on research and advocated the founding of a Corps of Aircraft Constructors similar to the Royal Corps of Naval Constructors. Mr. Ide read a communication from Mr. Warner, pointing out the difficulties of application of a standard procedure in connection with sections.

Professor Bairstow spoke of the extreme difficulty of standardising symbols and stated that a new subject needed more symbols than the other branches of engineering. The difficulties of introduction of any scheme of units were due to the possibilities of negative values being obtained for some of the derivative results. All objections to units could be met by using the absolute system. The time did not seem ripe for standardisation or, indeed, for any change.

Sir Richard Glazebrook, in replying to the discussion on his paper, agreed that the time taken in carrying out tests on the same models was very great, but if any other procedure were adopted the possibilities of errors were serious. The use of a different system of units for aeronautical work than those used in other branches of engineering introduced many difficulties. Credit was given to Lanchester for his work, but they must also recognise the great work on extending it which was done by Prandtl. He agreed with Colonel Malone and thanked him for his support in the demands for recognition of the value of research.

The morning session was brought to a close with an appeal from Mr. Ide for the broadcasting of all experimental results.

Extra-Light Alloys.

In Group A, under the presidency of Sir Robert Hadfield, a paper on "Extra-light Alloys and their Utilisation in Aeronautics" was contributed by Messrs. A. M. Portevin and R. de Fleury. It was read in abstract by Colonel C. Grard, D.S.O.

The paper called extra-light alloys those whose specific gravity was below 2, in order to distinguish them from the light metals and alloys having a specific gravity of from 2 to 3. It dealt with the alloys of magnesium, in which the proportion of added metals was sufficiently low for the specific gravity to remain below 2. The various chlorides of magnesium formed at the present time the principal sources from which the metal was obtained. Diagrams in the paper illustrated the influence of certain metals (aluminium, zinc, cadmium, copper) upon the mechanical properties of magnesium; the four metals named were those most frequently used. In regard to the modulus of elasticity, its increase was relatively smaller than the increase in tensile strength, elasticity and elongation. Thus, in order to obtain an increase of 10 per cent. in the modulus of elasticity, an addition of 4 per cent. to 5 per cent. of aluminium or zinc, and of 8 per cent. to 10 per cent. of copper, was required. The ternary alloys most in use were magnesium—aluminium—zinc alloys. The property of the alloys could, of course, be modified by cold work or annealing. The magnesium alloys could be supplied in the shape of castings; they could also be drawn, forged, rolled, worked under the hammer, turned and welded. Special attention was called, in the matter of castings, to the absolute necessity of most completely drying the sand moulds. The casting temperature should always be under 700 deg. Cent. Pieces could also be chill-cast. Welding gave excellent results whatever be the thickness of the piece dealt with. The paper called special attention to the general tendency when comparing together two metals having widely different specific gravities, of establishing a parallel between the specific gravities $\frac{D}{D_1}$ and the tensile strengths $\frac{R}{R_1}$. This was not sufficient, since the ratio of the moduli of elasticity $\frac{E}{E_1}$ was of no less fundamental importance. The authors expressed the opinion that two schools would now be inaugurated, one advocating for light structures the use of steel having a high tensile strength, and the other the use of light metals, particularly magnesium, the lightest of them. In their discussions the consideration of the modulus of elasticity would be found almost always to play a far more controlling action than the tensile strengths in limiting the possibility of making an aircraft unit as light as could be. Bringing in the modulus of elasticity, together with specific gravity and tensile strength, the authors compared aluminium with steel, magnesium with steel, and magnesium with aluminium. They found that, from the point of view of tensile strength and for equal weight, the light alloys could readily be compared to the special steels. The extra-light ones, magnesium in particular, were likely to possess marked advantages over all metals having a higher specific gravity, and even over aluminium.

Dr. Rosenhain found the paper of great interest. It dealt with a subject that had formed the object of research carried out at the National Physical Laboratory. Broadly speaking, the authors' work was in agreement with that of the National Physical Laboratory. Very light alloys were most attractive from various standpoints, but their utilisation was surrounded with very great difficulties. Their maximum tensile strength was in the neighbourhood of 18 tons per square inch, and that was only about half that of the best aluminium alloys. Another difficulty, and a serious one, had reference to corrosion, since pure magnesium was very corrodible, and the alloys of magnesium were more corrodible still. Means would therefore have to be found to prevent their rapid corrosion. Their cost was high, since magnesium was a very expensive metal. Further, it was more or less inflammable and its use was not to be recommended for engine parts subject to high temperatures. The authors had not referred to the physical properties, namely, the resistance of these alloys to alternating stresses, to alternate pressure and tension. In this connection these alloys, including the ordinary aluminium alloys, did not compare favourably with steel, and the power to resist alternating stresses was a most important factor for consideration. In the matter of the modulus of elasticity, he (the speaker) was not very hopeful; its improvement could not be effected to any very great extent. It might occur that we should be driven to use the hardest metals, such, for example, as tungsten, moving, therefore, in a direction quite opposite to the one followed by the authors. He did not think the ratios they had put forward were quite correct, for the strength of an alloy could be doubled by a slight addition of the copper content, an addition which did not alter the specific gravity to any material extent. In regard to casting the magnesium alloys, the doing of this in a neutral atmosphere was surrounded with very great difficulties. Air was about the best atmosphere to use; casting in vacuum was, however, better still, if this could be done. Here Dr. Rosenhain showed a specimen of magnesium which Dr. Jeffries had given him during his recent stay in the United States. The authors had stated that chlorides were almost the exclusive present source of supply, but the metal from which the specimen in question had been obtained had had no connection whatever with chlorides. He had brought over this specimen from the United States without giving it any protection whatever, and the crystals had retained all their brightness.

On the motion of the chairman, the authors and Colonel Grard received the thanks of the meeting.

AIRSCREW RESEARCH.

In Group B, which met in the Reading Room under the chairmanship of Brigadier-General R. K. Bagnall-Wild, the paper taken was one by Dr. H. C. Watts, relating to airscrew research in Great Britain. Dr. Watts, who is chairman of the panel appointed by the Aeronautical Research Committee to deal with airscrew research, explained that, during the war, this class of work was spasmodic and unorganised, so that it had been necessary to lay down as a fundamental principle that the more recent work should be done on airscrews having a known and definite relation to each other. A family of airscrews had, therefore, been designed and tested, using a standard aerofoil section, a standard blade shape, and a standard variation of blade thickness with length of blade. Many variables were thereby eliminated, and those left were pitch, aspect ratio and number of blades. In all, 26 different airscrews were made and tested, and the greater part of the work has been dealt with in a report now in the press. Some results, however, were given in the paper, and broad general conclusions deduced from these. For example, it is concluded that, for low values of the geometrical pitch, four-bladed screws are less efficient than two-bladed ones. Tests on screws having a constant total blade area, but different numbers of blades, generally confirm the widely-accepted view that, provided the total blade area remains constant, the efficiency will be constant; in other words, if the total blade width is the same, it is immaterial whether the width be divided among 2, 3 or 4 blades. Other points brought out are that, for low pitches, the efficiency is seriously affected by the total blade width, but with high pitches the total blade width has but little effect on efficiency. Other experiments referred to indicate that there is little to choose between a blade of constant pitch and one having a pitch which decreases or increases towards the tip. This fact has an important bearing on the design of metal airscrews.

Another part of the research had reference to the effect of bodies of various sizes situated either in front of or behind the screw. In general, it was found that the presence of the body increases both thrust and torque, the increase of the former being greater than that of the latter. This effect increases with the size of the body and is generally more marked for a tractor than for a pusher body. Experiments are being carried out with high tip speeds in order to determine at what speed the compressibility of the air begins to have a serious effect on efficiency. Some early results showed that compressibility effects were appreciable when the tip speed reached 0·85 of the velocity of sound in air, but there was some reason to suspect that the results were affected by the twisting of the blade; a preliminary research was, therefore, carried out to investigate this point. In the remainder of the paper the author traced the development of the various airscrew theories and referred briefly to that of Glauert. This theory, he said, was being checked against experimental results and, although the work was not yet complete, good agreement had been found with respect to total thrust and torque and also with experimental thrust-grading curves.

The only speaker in the discussion on this paper was Mr. A. Fage, who, after expressing appreciation of the paper, remarked that Mr. Glauert had placed airscrew theory on a sound foundation. The weakness of the inflow theory, which the speaker said he was partly responsible for, was that it had no logical basis. Further research, however, was necessary to fix the practical limitations to the Glauert theory. For this purpose use was being made of the data obtained from the family of airscrews tested at the National Physical Laboratory and referred to by the author. From the extensive data obtained it was possible to make generalisations with confidence, and the speaker thought the outcome might render necessary a careful scrutiny of the fundamentals of the Prandtl theory.

In thanking the author for his paper, the chairman referred to the need for further work, particularly on a full scale, and added, in connection with variable-pitch propellers, that means were required to enable the pilot to rotate the blades from the cockpit during flight. In this way it would be possible to obtain the maximum efficiency while climbing and also at cruising speeds. After the author had expressed thanks for the reception accorded to his paper the meeting adjourned.

THE SLOTTED WING.

One of the papers considered by a section of Group A, on Monday afternoon, of which meeting Sir R. T. Glazebrook acted as chairman, was by Mr. F. Handley Page, and dealt with the development of the slotted aeroplane wing. Mr. Page first described the device in a paper read before the Royal Aeronautical Society in February, 1921, which was dealt with in our columns at the time.* His present paper referred to subsequent work on the subject, and gave the results of wind channel tests on the application of the principle to various different wing sections. He mentioned that auxiliary aerofoils of what he described as the single-surface type, *i.e.*, formed of bent plates of uniform thickness, gave rather better results than the usual sections of varying thickness, and had the additional advantage that, in the closed condition, there was very little alteration to the true basic section of the wing. As a result of a very large number of tests, the data of which were given in the paper, an increase in lift of about 50 per cent. might be expected from a slot near the leading edge in the case of a wing of thin section, while a slotted flap would give an increased lift of about 40 per cent. With medium sections the increased lift obtained with front slots and slotted flaps would be 40 per cent. and 30 per cent. respectively, while the corresponding figures for thick sections would be 35 per cent. and 25 per cent. These figures, the author stated, could be obtained with full-sized machines, but he remarked that the actual increase due to the front slot depended upon the shape of the slot, and if a large increase in lift was obtained from the front slot the increase due to the back slot would be less. After discussing the control of machines with slotted wings and the effect of the slots on the design of aircraft, the author drew the conclusion that, in the case of an aeroplane having a normal landing speed, an all-round improvement in maximum speed, climb and height of ceiling could be obtained by the use of slotted wings.

Dr. A. G. von Baumhauer, who opened the discussion, asked for further information as to the reason for the increased lift obtained from the use of slots, and himself suggested the explanation that the extra lift was due to the fact that the angle of inclination of the auxiliary wing was steeply negative. He subsequently asked for further information as to the tendency of a machine with slotted wings to get into a spin. Mr. R. V. Southwell, who spoke on the invitation of the chairman, congratulated the author on having been able to make practical use of a device before the explanation of its action was forthcoming. The next speaker, Mr. H. Glauert, said that the employment of slots enabled a wing to be used at a higher angle of incidence, and that at the same angle of incidence the slotted wing was no better than a similar section without a slot. He added that, unless sufficient control were provided, it would not be possible to take advantage of the increased lift, and that with the necessarily powerful controls there would be the same risk of stalling as existed in any ordinary machine. Mr. R. McKinnon Wood confirmed the author's statement that the same increase in lift was obtained with a full-size machine as with a model tested in a wind channel, and Major F. M. Green asked for particulars of the wind channel in which the tests had been made. Major J. S. Buchanan added that full-scale tests of machines with slotted wings made by the Air Ministry had been satisfactory so far, but were not yet completed.

In his reply to the points raised in the discussion, the author first explained that, while Mr. Glauert's remarks with respect to stalling were quite correct, the controls could be arranged so that it was extremely difficult for the pilot to bring the machine to the stalling angle, and, with regard to spin, he pointed out that the lift curve obtained with the slotted wing had no very marked peak, such as was usually associated with the phenomenon of spin. In answer to Major Green, he stated that the wind channel used for the tests was 4 ft. square and the tests were made at a wind velocity of 40 ft. per second. The results corrected by Prandtl's method, he added, were in accordance with those obtained in the 7 ft. channel at the National Physical Laboratory and also with the Göttingen wind channel. They also agreed with the results obtained with full-sized machines.

* See ENGINEERING, vol. cxi, page 274.

AERODYNAMIC APPARATUS AT THE NATIONAL PHYSICAL LABORATORY.

After a short adjournment, the chairman called on Mr. R. V. Southwell to read his paper dealing with the apparatus and equipment recently constructed in the Aerodynamics Department of the National Physical Laboratory. The author first described the new 14 ft. by 7 ft. duplex wind channel, which he illustrated by means of lantern slides, remarking that the air velocity had been found to be within ½ per cent. of the mean over practically the whole working area. The roof balances used to measure the forces on the model, he said, were practically twice the size of those previously employed at the laboratory. They enabled the lift, drag and pitching moments to be determined in the usual way, and since either the sum or the difference between the lifts on each side of the model could be measured, it was possible to determine the rolling moment. He also explained the apparatus employed to measure all the component forces and couples on a model at large angles of pitch and yaw, as well as the apparatus for measuring the rotary derivative L*p*, which represents the damping in roll due to a given angular velocity of roll, and is required in connection with stability calculations. The apparatus used for testing the airscrews, dealt with in Dr. Watts' paper mentioned above, was also described, and another device referred to was a special form of Pitot tube used for determining the velocity and direction of the air in the neighbourhood of a solid body. This instrument makes use of the fact that the Pitot tube is very sensitive to the direction of the wind when set at an angle of about 45 deg. with the wind. Four small tubes, two in the vertical plane and two in the horizontal plane, are set with their open ends at an angle of 45 deg. with the longitudinal axis of the instrument, which is moved in both planes until the pressures in the tubes are equal. When this is the case, the axis of the instrument coincides with the wind direction, and the wind velocity is measured by a fifth tube in the ordinary way. The author finally described the large model of a "Bristol Fighter" aeroplane, which has been tested in the duplex wind channel, and dealt with the induction motor fitted in the fuselage of this model for the purpose of driving the airscrew. Some particulars of this interesting motor will be found on page 399, *ante*.

The discussion on this paper was opened by Dr. N. A. V. Piercy, who described an alternative method of measuring the direction and velocity of the wind, used at the East London College. The speaker remarked that in a stream-line body, similar to an airship body, it was possible to find a plane in the neighbourhood of the nose in which the pressure on the surface of the body was equal to the static pressure of the wind stream. Four tubes were fitted inside the body, with their open ends terminating in the surface in two planes at right angles, and also in the plane above referred to, in which the pressure is equal to the static pressure of the wind. The position of the body was adjusted so that the pressures in all four tubes were equal, and the axis of the stream-line body would then give the direction of the wind. The velocity was measured by another Pitot tube, terminating in the nose of the body.

The only other speaker, Mr. R. A. Bruce, asked for further information on the phenomenon of auto-rotation, which the author had referred to in describing the apparatus for measuring the rotary derivative L*p*, and, in replying to the discussion, Mr. Southwell explained that the phenomenon was the basis of the accident or manœuvre known as spin. A model, he said, if suitably mounted in a wind channel, would continue to rotate about its longitudinal axis if an initial rotation of sufficient

angular velocity were imparted to it in either direction. The experiment, he added, would be shown to the members of the Congress who visited the National Physical Laboratory on Thursday. The instrument referred to by Dr. Piercy, the speaker said, was new to him and was very interesting. It seemed to be very similar to the device described in the paper, and he thought it would serve its purpose equally well.

After the author had been thanked for his paper the meeting was adjourned.

THE UNIFICATION OF STANDARDS.

In Group A, under the presidency of Sir Henry White-Smith, the first paper taken on Monday afternoon was on "The Unification of Standards in Aeronautics," by Colonel C. Grard, D.S.O., who read it in abstract. The author emphasised the importance of working to standards from a national point of view, in order to secure economical production, and, from an international point of view also for the rapid exchange of the requisite material for aircraft construction. His paper was divided into two main parts, dealing with standards of quality and standards of form. The establishment of standards of quality demanded the determination of the characteristic features of the materials and the correct ascertainment of quality. In regard to testing, unification required a precise, or standard definition of the figures to be obtained; a standard specification of testing methods and apparatus giving evidence of the characteristic features of the metals, a standard definition of the test specimens and the adoption of a standard terminology. Chemical tests should also be standardised in order to secure greater uniformity in the results. In the matter of the elastic limit, in regard to which varied opinions existed, there had been adopted in French aeronautics a "practical" standard limit defined as follows: "The clause establishing for the elastic limit a value of n kg. per square millimetre is reckoned as having been met when the test-piece subjected to a load corresponding to the n kg. during 10 seconds, and then released, takes up its original length, an allowance of $\frac{1}{1,000}$ the length between gauge points being granted." The limit of elasticity thus defined has been adopted in France because it is one that can be measured, and to which it has been possible to give a standard definition. The use of the term "annealing" without reference to the critical point should be discontinued. The establishment of standards of form internationally, the author stated, was more difficult owing to the different units of measurement, but the problem was one quite possible of solution. Here he called attention to the recommendations of Colonel Renard and Mr. Rateau, according to which the dimensions of successive sizes of components formed a geometric progression. Germany had adopted this French system and had styled the resultant series "die deutsche Reihe." The French series would, for all practical purposes, meet British dimensions, thus 1 in. = 25·4 mm. would correspond to the French 25 mm.; 2 in. = 50·8 mm. to 50 mm.; $\frac{1}{2}$ in. = 12·7 mm. to 12·5 mm.; $\frac{1}{4}$ in. = 6·35 mm. to 6·3 mm., and so forth. They are therefore also applicable to Great Britain.

Mr. C. le Maistre then read a paper on "Aircraft Standardisation," in which he laid emphasis on the necessity of avoiding any step which would hamper progress in design by premature standardisation, but agreed that no risk of this kind would be incurred if international agreement was reached as to the precise signification to be attached to technical terms in common use, and as to methods of testing materials. He stated that during the war the Air Ministry had called upon the British Engineering Standards Association to draw up specifications for aircraft material, and these had proved satisfactory both to the Ministry and to the manufacturers. In all, some 200 specifications had been issued. The specifications now in use were, in fact, based on these, but they were being continuously revised and brought up to date by a special committee. These specifications had proved useful in other industries, certain special steels originally introduced to meet aircraft requirements being now utilised for motor cars. Something had also been done to unify nomenclature, and a glossary of aeronautical terms brought up to date had been issued by the Standards Committee, and similar work had been undertaken in connection with the terms used in radiography.

It would, he thought, be difficult at present to secure interchangeability of components, but it was very desirable to reduce the multiplicity of different types now in use. On the other hand, any attempt to unify complete machines or main component parts would be disastrous. Whilst, therefore, the time had not yet arrived for the issue of general international aircraft specifications, there were a number of minor points on which agreement might be secured. Many of those whom he had consulted had expressed a desire to resuscitate the International Commission of Aeronautical Standards which was created during the war. In conclusion, Mr. C. le Maistre observed that the term "standardisation" lent itself to misconception. It would be better to employ the word "unification," which would not involve the implication of such a crystallisation of practice as would be a bar to progress.

After a discussion, in which the views expressed in the two papers were accepted and emphasised, the following resolution was passed:—

"That this International Air Congress assembled in London, in June, 1923, invite the International Convention of Air Navigation to consider the advisability of setting up a permanent International Commission for standardising aircraft material and component parts, and for this purpose to invite delegates from various national standards organisations to meet and report on the matter."

On Monday evening the members attended a reception held at the Hotel Victoria, by the President of the Congress, H.R.H. the Duke of York, and the following day, as well as Thursday, the 28th inst., were occupied with visits and excursions to places of aeronautical interest. The reading and discussion of papers was continued on Wednesday, the 27th inst., and will be concluded to-day; we propose to deal with some of the remaining papers and discussions in subsequent issues. The final meeting of the Congress will take place to-morrow morning, when the chair will be taken by the Right Hon. Sir Samuel Hoare, Secretary of State for Air. The social functions included in the programme of the Congress comprised a reception by the Lord Mayor at the Mansion House on Wednesday, a reception by the Duchess of Sutherland at Hampden House, on Thursday, an official visit to the Science Museum, South Kensington this evening, and a banquet at the Hotel Victoria to-morrow evening. Special arrangements have also been made for the members to visit the Royal Air Force Pageant at Hendon to-morrow afternoon.

(To be continued.)

ATOMIC PROJECTILES AND THEIR PROPERTIES.

At the close of the season of the Royal Institution on the 16th inst., Sir Ernest Rutherford, F.R.S., was able to conclude his course of six lectures on "Atomic Projectiles and Their Properties," delivery of which had been interrupted before Easter by his indisposition, as we pointed out at the time. Our abstract of the fifth lecture appeared on page 358 of our issue of March 23.

Briefly recapitulating the line of argument of his last lecture, Sir Ernest said that the study of collisions between swift α particles and hydrogen nuclei (protons) enabled us to draw conclusions as to the structure of the nucleus. Assuming first for simplicity sake that all the complexity belonged to the α particle and that the proton was merely a point charge, he had shown that the α particle must be a field of strong forces and of sensible dimensions. According to the calculations of C. G. Darwin and the experiments of J. Chadwick and E. S. Bieler the α particle might be a spheroid, of the axes $a = 8 \times 10^{-13}$ cm. and $b = 4 \times 10^{-13}$ cm. The law of inverse squares held outside that spheroid; it would not hold inside, and any particle penetrating into the spheroid would meet a rapidly increasing force field. In this consideration the α particle had, to simplify matters, been supposed to be the target at rest whilst the hydrogen nucleus was the projectile; that was frequently convenient.

To-day, Professor Rutherford continued, he was going to give an account of the application of this method to the attack of an atom; but he would first consider some theoretical points. Imagine the nucleus of an atom of RaC as a sphere and let an α particle be fired out of it; that particle would start at zero velocity or at some positive velocity. If we imagined the process reversed, a particle shot from outside, reaching the sphere and the actual structure at that velocity, need not much disturb the nucleus. The distance at which an α particle could approach the nucleus of a very heavy atom, say of atomic number 80, was 4×10^{-12} cm.; the α particle would then be reflected. In the more promising case of a lighter atom like oxygen (atomic number 8)—the dimensions of which were not known—the α particle might get 10 times closer, *i.e.*, within one-tenth of the just stated distance, or 4×10^{-13} cm., which was roughly the dimension of the α particle itself. The α particle might in a head-on collision, therefore, reach the structure with considerable energy and might disturb or disintegrate it. That was the idea underlying the experiments, and he had been guided by another point of view. Supposing he had disintegrated an atom. For various reasons it had long been assumed that the helium nucleus of mass 4 was one of the constituents building up other atoms. Thus oxygen $O = 16 = 4He$; but that would not apply to nitrogen $14 = 3 \times 4 + 2$, where there were two units of something else, probably protons of mass 1. We had, of course, to remember that the atom also contained negative atoms of matter; they were even present in helium, since its mass was 4 and its charge 2; the charge was always the resultant charge.

In discharging now α particles from RaC into air he had noticed a peculiar effect; particles appeared which travelled at high speed far beyond the range of the α ray, and made the zinc sulphide screen scintillate. The effect was the first observation of the disintegration of nitrogen. But in those days it had been very difficult and laborious to count those few, feeble light flashes, and the later progress was mainly due to improvement in the technique, especially in the microscope. They wanted a magnification of about 50 and an object glass of wide aperture and very short focus; Professor Conradi had designed such a microscope. As it would be unpleasant to have the eye within 6 in. of the RaC, the source of the α particles, Mr. Twyman and Messrs. Hilger had constructed a microscope which resembled a telescope; the object end was closed, and the lens was placed in a short vertical side tube at that end, the rays being turned at right angles in the telescope. Further to enlarge the field, Sir Ernest had constructed a similar microscope provided with a holoscopic lens; this gave a field of nearly 8 mm. square, which was divided into 64 squares by a screen of copper gauze. To compensate for the distortion of the image, the disc, on which the radioactive source was placed, was slightly curved.

The experimental apparatus (Fig. 40) was a brass tube, about 3 cm. diameter, provided with a hole at one end generally closed by a disc of silver. The source, an invisible film of RaC, was coated on the brass disc R, which could be shifted with its horizontal rod. The α particles were discharged into the gas in the chamber either directly, or through the material to be studied, a plate of aluminium or of paraffin or some compound dusted on a foil of metal, mounted immediately in front of R. In the recess, about 1 mm. wide, between the window and the sulphide plate S were placed absorbing screens of mica or metals in order to reduce any inconveniently large numbers of scintillations. When the gas in the chamber was dry oxygen, there were very few scintillations, and these were subsequently traced to hydrogen, the presence of traces of which it was almost impossible to avoid; those scintillations due to free hydrogen constituted the "natural effect" which had to be allowed for, and had nothing to do with the oxygen.

When the oxygen was replaced by nitrogen, the number of particles increased, and the "long-range" particles liberated travelled 28 cm., and more, the range of the α particles themselves being 7 cm. In Fig. 41 the results of experiments with various substances are summarised. The abscissæ are the

equivalent ranges in dry air, the ordinates are the numbers of scintillations observed per minute per milligramme of activity of RaC for the microscope used. The bombardment of nitrogen (dry air) yielded particles of a range of 40 cm. The mixture of $(CO_2 + H_4)$, of approximately the stopping power of air for α rays, gave scintillations which were very strong for the range about 20, but then fell off rapidly then. When the particles were liberated from hydrogen, no matter where the hydrogen came from (moisture, paraffin wax, compounds), the range of the particles never exceeded 29 cm. The bombardment of an aluminium plate (placed in front of R), however, gave particles of a range of 90 cm., going beyond the scale of Fig. 41. The curve C, marked oxygen, showed the "natural effect." Similar experiments were then made with a large number of substances, including compounds of the iron group. But the capability of liberating long-range particles was found to be restricted to six "active" elements (and their compounds), namely: Boron, nitrogen, fluorine, sodium, aluminium, and phosphorus. The ranges attained (to be given presently) were only approximate, Sir Ernest remarked; for it was very difficult to estimate the thickness of the films dusted or condensed on the

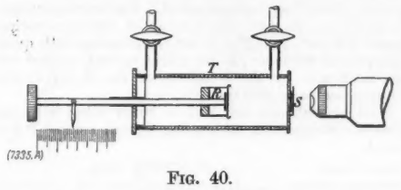


FIG. 40.

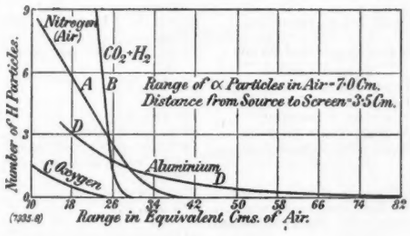


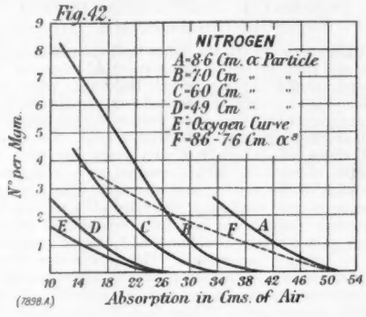
FIG. 41.

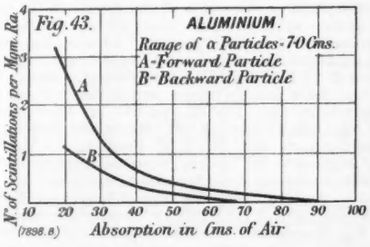
metal foil; in some of the nitrogen experiments paracyanogen CN was used to provide a solid material.

Further researches proved that the ranges of the scintillating particles varied proportionally to the velocity (and ranges) of the bombarding α rays emitted by various substances. In Fig. 42 these latter ranges are shown decreasing from 8·6 cm. (for the swiftest thorium rays in curve A) down to 4·9 cm. (curve D). The corresponding changes in the α ray velocity would not much exceed 10 per cent., but that made a great difference in the long-range particles. All the curves referred to the bombardment of nitrogen; the dotted F curve was obtained by cutting the speed of the thorium rays gradually down by means of silver screens. Similar experiments with bombarded aluminium showed that when the velocity of the α rays fell much below a certain minimum (stopping power of less than 5 cm.), all liberation of long-range particles ceased.

But these experiments brought out another important point. The liberated particles were expelled in all directions, backward nearly as well as forward. To study this further the apparatus shown in Fig. 40 was so modified that the back of the silver disc R (now used), and not the other surface coated with RaC, was made to face towards the screen. Again it was found that the backward expulsion of particles was restricted to the six "active", elements mentioned and the ranges were found to be, in centimetres forward (and backward): Boron 58 (38); nitrogen 40 (18), fluorine 65 (48), sodium 58 (36), aluminium 90 (67), phosphorus 65 (49). All the backward ranges were thus shorter than the forward ranges, but the difference was very marked only in the case of nitrogen. The trends of the two curves A and B, Fig. 43, showed that in the case of aluminium the phenomena were roughly the same for forward and backward expulsion; and that applied to the other elements.

What now was the nature of these scintillating particles? It had appeared clear from the beginning that they must be hydrogen nuclei. To verify this the apparatus, Fig. 44, was used. The source was placed on a bar R which was mounted slanting to the horizontal; the lower edge of R was level with the brass plate S which acting as a slit did not allow any liberated particles to strike the screen below its middle at E. When the magnetic field was turned on to deflect the beam of particles, no sharp edge could be obtained, the numbers of particles being too small. The field was therefore reversed alternately, so as to obtain upward or downward deflection of the beam. Supposing the particles to be positively charged, there should be more scintillations with a negative field than with a positive field, and calculations could be based upon the two deflections compared to the number of the deflections obtained with hydrogen particles of known velocity. These experiments and calculations, made by placing first paraffin, and then aluminium in front of R, left no doubt that the long-range particles were





really hydrogen nuclei of mass 1 and charge 1, though any chemical identification of the hydrogen was quite out of the question.

But how could that expulsion in all directions of hydrogen nuclei, from aluminium be explained? The hydrogen nucleus H might form a "satellite" of the aluminium nucleus, describing its orbit about the latter, as in Fig. 45, where the N marks the aluminium nucleus [the N has nothing to do with nitrogen].

Referring to the diagrams in Fig. 45, Sir Ernest Rutherford observed that an α particle coming on as shown at A in that diagram would drive the H forward; but a particle coming on as shown at B would drive the H down and make it turn about N so as to come out apparently in a backward direction. Scattering in other directions might be explained on these general lines. That explanation would involve the hydrogen nucleus as a satellite of atomic systems. Looking at the table of the elements we saw that the six "active" elements (marked by a bar) all had odd atomic numbers, which formed a natural sequence 5, 7, 9, 11, 13, 15, beginning and ending abruptly, and Sir Ernest had found, that neither the intermediate elements of even numbers, nor the others of odd numbers, especially lithium 3 and chlorine 17, showed any signs of this special activity. Further the six were all "pure" elements, in the sense of being devoid of isotopes [with the exception of boron, however, which had two isotopes of masses 10 and 11].

It was, moreover, remarkable that the atomic masses of all the six elements could be represented by the formula $4n + a$, where a was mostly 3, but 2 in the case of nitrogen (and of the one boron). Thus nitrogen stood somewhat apart from the other

Element.	Atomic No.	Mass.
H	1	1·008
He	2	4
Li	3	6·7
Be	4	9
▮B	5	10 or 11
C	6	12
▮N	7	14
O	8	16
▮F	9	19
Ne	10	20, 22
▮Na	11	23
Mg	12	24, 25, 26
▮Al	13	27
Si	14	28,29
▮P	15	31
S	16	32
Cl	17	35, 37

active elements, and this was noted also in the energy estimates. If we supposed that the shooting out of the particles, forward or backward, occurred without loss of energy, we could make calculations. Presuming that the law of conservation of momentum held, and that the sum of the energies of the liberated

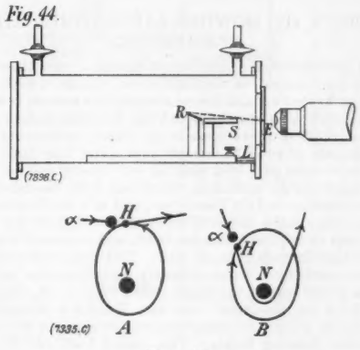


FIG. 45.

hydrogen nuclei and of the residual nucleus struck, of aluminium, for instance, was the same for forward and backward expulsion, we had in the energy calculations to consider a system of three components, the two nuclei mentioned and the bombarding α ray. Exhibiting a table of the results of these calculations, Sir Ernest pointed out that, whilst in five of these cases the hydrogen nuclei gained energy by the disintegration (6 per cent. in the case of sodium, 42 per cent. for aluminium), there was an energy loss of 13 per cent. in the case of nitrogen. The experiments were very difficult and all the effects observed exceedingly small; so far only the scintillation method was available, and only one α ray of a million might drive out a proton. That illustrated the fact that the nuclei were far too small to be likely to be hit. Yet the number of hydrogen nuclei liberated from nitrogen was only one-seventeenth of the number one would expect, if the hydrogen formed an ordinary component of the nucleus. If it were a "satellite," however, the chances of expulsion would be still more remote. When the nitrogen nucleus was hit, only very swift projectiles would be able to disturb the system sufficiently to shake off the satellite. The energy estimates which had been made suggested that the satellite was relatively close to the nucleus of nitrogen and strongly bound.

That brought up further interesting points, as Sir Ernest remarked in coming to his conclusion. Both the nucleus and the satellite carried positive charges; yet they were supposed to attract one another in these satellite orbits, and that implied that, at some very close range, the forces which were generally repulsive became attractive. The mere fact that the nucleus of any atom held together indeed indicated that there must be a change in the force, actually as to sign. That was a great difficulty, as we did not understand the nature of these forces. The disintegration experiments, he had described, suggested that some light elements contained proton as a constituent. Those six elements were of odd atomic numbers; experiments

with other odd elements and with even elements had failed. Now, according to W. D. Harkins (Chicago), elements of even atomic numbers were far more abundant than odd-number elements and probably more stable, and the six active elements might gradually break up. The two hydrogen satellites in nitrogen might describe orbits and be knocked off together in collisions; if the aluminium nucleus had three hydrogen satellites, two might be in a pair and differing from the third.

All those were open questions. Further ocular disintegration evidence by the Wilson method was very desirable. Close examination of the Wilson photographs should reveal the three tracks of the α ray, the hydrogen nucleus and the residual nucleus. Professor Chander Bose, of Calcutta, thought he had recently obtained such tracks. But we should have to examine thousands of photographs and hunt for three or more tracks instead of the now familiar forks. That would be done in the coming years. The study of collisions was certainly one of the most powerful methods of solving problems of structure; and he had, in his discourse of the previous evening,* referred to another matter of fundamental importance, the capture of electrons.

TESTS OF HOWDEN-LJUNGSTRÖM AIR PREHEATER.

THE association of the firm of Messrs. James Howden and Co., Limited, of Scotland-street, Glasgow, with the use of heated air and forced draught for marine boilers is of very long standing, and the Howden system has been applied to thousands of vessels containing an aggregate of over 24,000,000 h.p. The firm have for some months past been making very careful tests of the Ljungström air preheater, which was fully described in our columns on July 7 last year, and as a result of these tests they have acquired an exclusive licence for the system as applied to marine work, and a general licence for land installations as well. The tests referred to were carried out on an ordinary Scotch marine boiler. The boiler was of the single-ended type, 11 ft. long by 9 ft. 6 in. diameter, with two Deighton corrugated furnaces 31⅞ in. internal diameter fitted with Howden patent furnace fronts. The boiler had 146 tubes, 2·5 in. diameter by 7 ft. 6 in. long. The heating surface of the tubes was 716·13 sq. ft., of the furnaces 80·5 sq. ft. and of the combustion chamber 113·37 sq. ft., making a total of 910 sq. ft. The grate area was 24 sq. ft., excluding the dead plate.

TABLE I.—*Summary of Test Figures obtained from Cylindrical Type Marine Boiler, fitted with Howden-Ljungström Air Preheater, at Works of James Howden and Co., Limited, Glasgow.*

Two furnaces, 31⅞ in. diameter, grate area 24 sq. ft. Total heating surface with coal, 910 sq. ft. Total heating surface with oil (bars removed), 1,036 sq. ft. Retarders in tubes.

Conditions.	Coal Burning.		Oil Burning.	
Date	31/1/23	14/2/23	5/3/23	6/3/23
Duration—hours	5	4	4	4
Steam pressure, lb. per sq. in.	164	167	161	161
Average feed temperature deg. F.	180	165	179	172
Class of fuel	Scotch Coal	Scotch Coal	Mexican Oil	Mexican Oil
Calorific value of fuel—B.Th.U.	13,055	12,300	17,574	17,574
Fuel burned per hour, lb.	540	636	453	495
Equivalent evaporated per lb. Fuel, lb.	11·12	10·19	15·97	15·76
Equivalent evaporation, per sq. ft. H.S., lb.	6·6	7·12	6·99	7·54
Temperature of flue gases entering air preheater, deg. F.	538	561	537	554
Exit temperature flue gases, deg. F.	217	231	195	215
Temperature air entering fan, deg. F.	76	66	77	77
Temperature of air leaving preheater, deg. F.	419	427	426	427
Temperature of air entering furnaces, deg. F.	405	415	398	409
Air pressure in reservoir around furnaces, in., W.G.	0·35	0·34	0·31	0·32
Air pressure at furnace door, in., W.G.	−0·06	0·02	0·16	0·15
Air pressure at ashpit door, in., W.G.	0·30	0·30	0·24	0·23
CO_2 in flue gases, per cent.	9·5	9·0	11·1	11·0
Thermal efficiency of boiler	84·36	85·49	87·6	87·13

The heating of the air supplied to the furnaces was effected by an air preheater of the Ljungström type, situated at the top of the uptake, and consisted of a cylindrical rotor, filled with a honeycomb arrangement of thin corrugated steel sheets, so arranged that the hot flue gases passed axially through one-half of the rotor, and the air for combustion passed in a contrary direction through the other half as the rotor slowly revolved. Two small fans on a common shaft propelled the air and gases along their respective paths. The total heating surface of the preheater was 5,110 sq. ft. There is in this type of apparatus no attempt at the transfer of heat from the flue gases to the incoming air through a metal wall. The rotor itself is heated by the gases, and the heat is swept off by the air for combustion.

All precautions were, of course, taken to ensure that tests intended to be comparative were carried out under as nearly identical conditions as possible, and they were supervised by engineers representing both parties concerned. Some of the results obtained are given in Table I.

It will be noted that on one test the temperature of the flue gases was reduced to the extraordinary low figure of 195 deg. F. Even if it were practicable to obtain equal results with an economiser it would be very inadvisable to attempt such a reduction of temperature because of the condensation of moisture on the tubes. The efficiencies obtained will be recognised as quite extraordinary ones for any boiler, especially in view of the comparatively large amount of excess air which was passing through the fires.

* See ENGINEERING, June 22, page 769, *ante*.

THE FRANKLIN-STEPHENSON OIL-BURNING FURNACE.

THE absence of coal, and ashes with their inseparable dust and dirt, makes oil-firing peculiarly suitable for boilers installed in residential buildings, while the saving of labour which the method renders possible, is an advantage which is of even greater consideration in connection with large industrial plants. The great coal strike which occurred two years ago gave an impetus to oil firing which resulted in a widespread extension of the system, and although, with a return to more normal conditions, the interest in oil fuel has somewhat abated, this fuel fully retains the ground it has gained where cleanliness and ease of operation are of primary importance. The satisfaction which oil fuel will give is, however, largely dependent upon the efficiency of the burner and the suitability of the furnace arrangement. These factors affect both the economy and smokelessness of the plant and the cost of upkeep as well. The manufacture of oil-fuel burners, known as the "Victory" burners, has been a speciality of the Projectile and Engineering Company, Limited, of New-road, Wandsworth-road, London, for several years, and the furnace arrangements which we illustrate in Figs. 1 to 5, opposite, are the outcome of the collaboration of Mr. Harry Stephenson of that company with Mr. G. H. Franklin, M.I.Mar.E., the engineer to St. Thomas' Hospital, London.

Before referring to the furnaces themselves, it will be well to describe briefly the type of burner employed. A section through the "Victory" burner is reproduced in Fig. 6, opposite. The fuel oil is fed by gravity to the burner through the central pipe and is vaporised by either hot air or steam, the latter serving more as an auxiliary or stand-by method. The central pipe mentioned terminates in a long conical nozzle. The oil emerging from the nozzle strikes the inner end of the bronze cap. This breaks up the stream of oil which finally escapes through 12 small holes round the circumference of the cap. The other pipe connection, shown pointing vertically upwards in the illustration, admits steam to an annular jacket surrounding the oil pipe for the purpose of heating the oil. From this jacket the steam can escape through a small hole which leads it into the interior of an adjustable brass sleeve having a very slight annular clearance around the edge of the nozzle cap. Escaping through this clearance the steam strikes the small oil jets and impels the oil into the furnace in a very finely divided state. Under normal conditions, this steam may be entirely shut off, as the heated primary air supply is quite sufficient to produce the required effects.

The parts which we have described will be seen to be surrounded by a cast-iron angle pipe. The lower branch of this angle-piece is connected to the supply of the primary combustion air, the secondary air being drawn into the furnace by the action of the burner. This primary air is heated by passing through pipes or ducts in the brickwork of the furnace itself, so that it promotes an efficient and intense combustion of the spray of fuel. Figs. 1 to 3, opposite, show the application of the Franklin-Stephenson system to one of the water-tube boilers at St. Thomas' Hospital. At each side of the furnace there are a pair of burners, which although identical have normally different functions. One of each pair acts as a burner in the manner described, while a hot air blast only is delivered from the other, the oil being shut off. The burner, which is alight on one side of the furnace, is exactly opposite the one which is not alight on the other side, so that each flame is confronted with an opposing blast of hot air. This stops the flame at any point in its line of direction, according to the strength of the opposing blast, and spreads it out in a volume of intense combustion. By regulating the strength of the opposing blast the flame can be stopped at any desired point in the furnace width. Usually, of course, both flames terminate in the centre of the furnace, and equally obviously all four burners can be supplied with oil if it is desired to force the boiler.

An inspection of the interior of the furnace through a sight hole shows that when the flames are stopped by the opposing air they appear to be deflected downwards towards the incandescent surface of the furnace hearth, the space under the tubes being quite clear of flame, as indicated in the drawing. The absence of flame in contact with the comparatively cold tubes ensures smokelessness, and the exposure of the whole of the tube surface above the furnace to the intense radiant heat from the incandescent hearth, without shielding from arches or other obstructions, results in a very high rate of steaming. The air to the burner is supplied by a fan or blower, as shown in Fig. 3, its temperature being raised to about 150 deg. F. by passing through the pipes underneath the furnace.

The boiler in question is of the cross-drum land type manufactured by Messrs. Babcock and Wilcox, Limited, working at 80 lb. per square inch, and delivering superheated steam to calorifiers, from which the hot water system of the hospital is supplied. The heating surface is 2,382 sq. ft. and the volume of the combustion space 200 cub. ft. The boiler is operating with quite exceptional efficiency, as the following test, carried out independently by the engineers of the Boiler House Supply Company, will indicate.

Test on Babcock and Wilcox boiler fitted with the Franklin-Stephenson oil-burning system using "B.P." oil:—

Date of test	April 19, 1923.
Duration of test	10 a.m. to 6 p.m.—8 hours.
Total oil used	5,803·6 lb.—725·4 lb. per hour.
Total water evaporated	96,000 lb.—12,000 lb. per hour.
Water evaporated 96,000 / Oil used 5,803·6	16·54 lb. water per pound oil.
Temperature of feed water	178 deg. F.
Temperature of feed water leaving economiser	195 deg. F.
Average steam pressure	80 lb. per square inch gauge.
Equivalent evaporation	18·2 lb. water per pound oil from and at 212 deg. F.
Efficiency of boiler plant	93·2 per cent.
Oil feed temperature	133 deg. F.
Maximum observed steam pressure	85 lb. per square inch gauge.
Minimum observed steam pressure	75 lb. per square inch gauge.
Average temperature of superheated	380 deg. F.
Average CO_2 test	10 per cent.
Average temperature of flue gases	250 deg. F.
Calorific value of oil	19,000 B.Th.U. per pound.
Specific gravity of oil	0·897.

The application of the Franklin-Stephenson system to internally-fired boilers is illustrated by Figs. 4 and 5, opposite, the arrangement being that used in the Lancashire boilers at St. Thomas' Hospital. The ordinary firebars are removed and the furnace lined with firebrick for a length of 7 ft. from the front end, which is also closed with brickwork. A brickwork column stands up in the flue at the end of the furnace. The air for combustion is preheated by passing through a pipe in the bottom flue of the boiler in the manner shown. Part of this air goes to the burners and part is tapped off and passed through a port in the furnace bottom and up through the column to form the opposing blast, which is characteristic of the system. A test on those boilers, also carried out by the Boiler House Supply Company, is given below, "B.P." oil being used:—

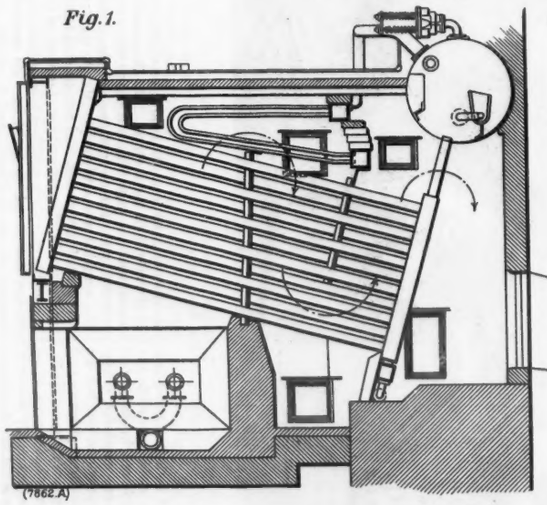
No. 3 Boiler.

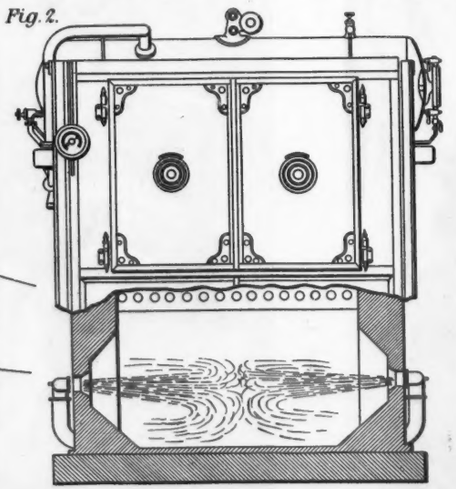
Date of trial	September 22, 1921.
Duration of trial	8 a.m. to 5 p.m.—9 hours.
Steam pressure in boiler	78 lb. per square inch.
Temperature of feed water	60 deg. F.
Temperature in economiser	176 deg. F.
Total amount of oil consumed	339 gallons.
Amount of oil consumed per hour	37½ gallons.
Amount of water evaporated	4,300 gallons.
Amount of water evaporated per hour	477¾ gallons.
Water evaporated per pound of fuel	13·49 lb.
Water evaporated per pound of fuel, from and at 212 deg. F.	16·05 lb.

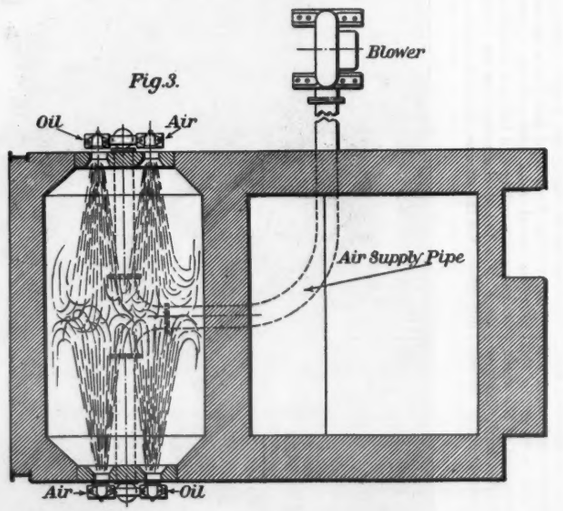
Besides the application to boiler furnaces, the system of oil-burning which we have described has found a

THE FRANKLIN-STEPHENSON OIL-BURNING FURNACE.

CONSTRUCTED BY THE PROJECTILE AND ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.







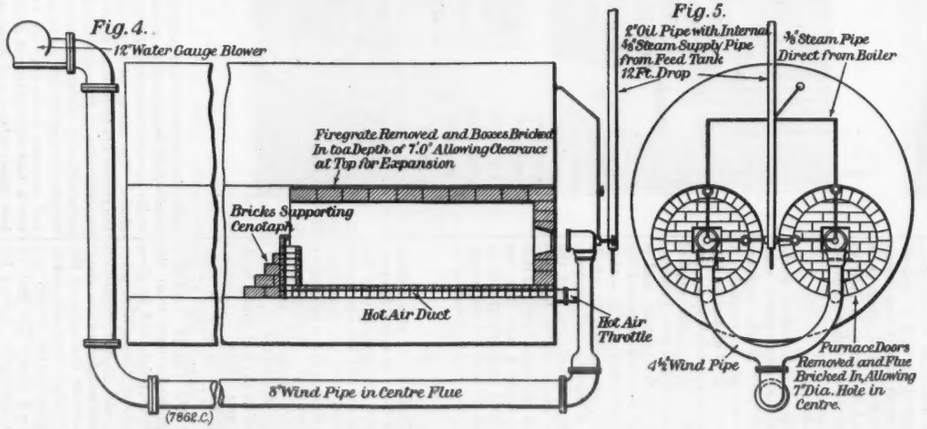
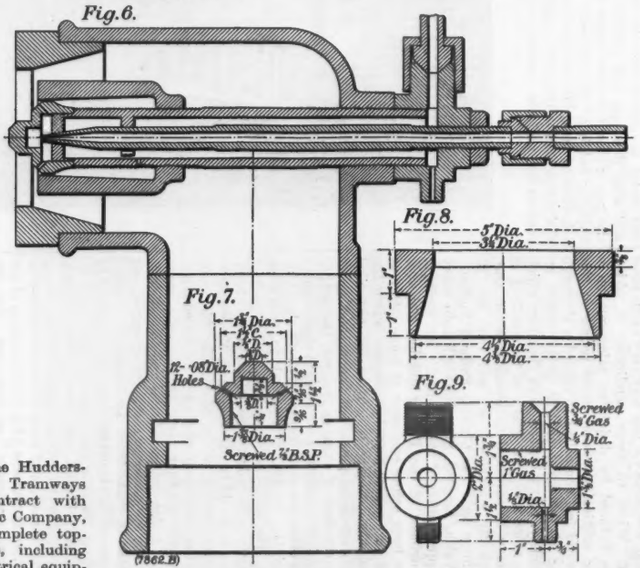


Fig.4.
1½" Water Gauge Blower
Firegrate Removed and Boxes Bricked In to a Depth of 7.0" Allowing Clearance at Top for Expansion
Bricks Supporting Cenotaph
Hot Air Duct
8" Wind Pipe in Centre Flue
(7862.C)
Fig.5.
2" Oil Pipe with Internal ⅜" Steam Supply Pipe from Feed Tank 12 Ft. Drop
⅜" Steam Pipe Direct from Boiler
Hot Air Throttle
4½" Wind Pipe
Furnace Doors Removed and Flue Bricked In, Allowing 7" Dia. Hole in Centre.



considerable field of usefulness in connection with the heating of furnaces for billet-heating and other purposes. The Projectile and Engineering Company, Limited, who have carried out the work on the boilers which we have illustrated, are large users of heating furnaces in their ordinary manufacturing operations, and they have applied the system to these furnaces with great success. Preheating of air by the waste furnace heat and the opposed blast for completing combustion and regulating the position of the flame, characterise this application of the method equally with the others. Tests carried out at the Projectile Company's works show that a furnace using 2,000 lb. of "B.P." oil during a 10-hour shift would heat 9 tons of billets, whereas a corresponding coal-fired furnace burning 6,720 lb. of coal only had an output of 7·25 tons of billets. With coal costing 36*s.* per ton and oil costing 70*s.* per ton this represented a saving of nearly 7*s.* per ton of steel heated for fuel alone, without considering the advantage of the greater output and the absence of stoppages for the cleaning and clinkering of the furnaces. The Franklin-Stephenson system would appear suitable for any type of furnace whether for steam raising or otherwise, and it is considered particularly adaptable to marine purposes.

CONTRACTS. — The Huddersfield Corporation Tramways have placed a contract with the English Electric Company, Limited, for 10 complete top-covered tram cars, including trucks and the electrical equipments, comprising D.K. 30 motors and D.B. 1 K. 3 controllers.—The Underground Company have placed a contract with Messrs. J. Parkinson and Son for the construction of a station at Edgware. This will be the terminal station of the new extension line which is now being constructed between Golder's Green and Edgware. The station will be erected in Churchlane, Edgware, and the plans include a forecourt, similar to that at Golder's Green, which will form a convenient base for the operation of motor-'bus services. The cost of this new station building will be 16,690*l.*

NOTES ON NEW BOOKS.

CHINA is so large a country, and still, in spite of all improvements in communications, relatively so distant, that the average European yet has only very vague ideas concerning it. When to these conditions is added the confusion induced by disjointed telegrams on a very complex political situation, most people in this part of the world feel compelled to regard a thorough understanding of the ways of that great nation an utter impossibility. Any concise work therefore which will enable a more adequate grasp to be obtained of the country may be expected to arouse interest, and, although distinctly specialised, we feel that Mr. H. Stringer's volume on "*The Chinese Railway System*" (Kelly and Walsh, Limited, Shanghai) will help many to a better appreciation of the country. Mr. Stringer is resident engineer of the Peking-Mukden Railway. His name has been before engineers at home lately as the author of two papers read last session before the Institution of Civil Engineers. After an historical sketch of railway development in China, and space devoted to particulars of existing systems, the author concerns himself with railway economics in that country with notes on other forms of transport available. The latter part of the volume is devoted to the more practical side, the subjects dealt with being pioneer railway location, and railway construction in China. These chapters, as would be expected from Mr. Stringer, are very practical and would be of considerable value to any one embarking upon new work in the country. It is questionable whether they are fittingly made appendages to a description of the railway system, and on the whole we prefer to see them separated and elaborated so as to make them applicable to a wider field, in the manner in which they have been treated in "*Pioneer Railway Engineering*" (Messrs. H. F. and G. Witherby, London: 12*s.* 6*d.* net), also by Mr. Stringer. The latter work can be recommended to all young engineers going abroad, and need not be restricted to railway circles, for it contains a lot of information of the type which young engineers "on their own" for the first time in foreign countries or the Colonies, cannot fail to find of value. Though concerned mainly with railway work a good deal of space is devoted to general construction, small buildings, water supply and much other matter than railway topics. The work is a glorified practical note-book, and its service is likely to be enhanced by the blank leaves for further notes by the happy possessor of the volume.

Although a good many excellent and modern works are available on hydraulics, the number which view this subject from the point of view of the engineer interested in drainage and sewage is limited. A volume which compresses a good deal of matter on this particular aspect of the subject into a small space has recently appeared under the title "*Hydraulics Applied to Sewer Design*" (Crosby Lockwood and Son, London; 10*s.* 6*d.* net). This is by Mr. G. S. Colemar, and is based on notes of courses of lectures delivered by him to technical institutions in Manchester. The author has drawn on many sources for his matter, to which due acknowledgment is made. The condensed character of the book makes it a little fragmentary, and the author's comments sometimes strike one as headings for extemporised elaboration in the class-room, as it is probable they really are. It seems a pity that one series of symbols could not be used throughout and an index of them given a prominent place at the beginning, while a printer's error or two will need attention in any future editions.

When we speak of the fixation of atmospheric nitrogen, we are apt to overlook that the actual fixation, *i.e.*, the oxidation of the sluggish nitrogen, is only the first stage of the problem. Technically the absorption of the nitric oxide, highly diluted with air, constitutes the second more difficult stage, though in the laboratory that second stage looks simple enough. Without quite agreeing to Mr. H. W. Webb's statement that the absorption process is very often conducted on rule-of-thumb methods, we do not question the fact that a book like his "*Absorption of Nitrous Gases*" (London: Edward Arnold and Co.; price 25*s.* net) is very opportune. Mr. Webb, M.Sc., F.I.C., is head of the department of Chemistry of the Cardiff Technical College. He deals with his problems both from the theoretical and the technical standpoint, and he gives collective information on the construction of absorption towers, their filling materials, and on gas circulation and measurements. More definite information about actual works' practice would add to the value of the book, and the works referred to might be mentioned in the indexes (names and subject-matter) which are otherwise commendable. Recent papers like that by Hall, Jacques and Leslie, on absorption towers for nitric acid should have been noticed, and in the case of acid mist treatment we might well have been given more references.

THE MANUFACTURE AND PROPERTIES OF WELDLESS CHAINS.

WHEN chains are made in the ordinary way the round bar metal is formed into the shape of an open link, and after it is put into position on the previous link, the gap is closed by the simple process of heating and hammer welding. When every care is taken in the selection of material and the production of the welds, the chains will withstand considerable loads and give reasonably uniform results. Unfortunately human activities are not always performed with that thoroughness which is essential, and some weak or indifferent welds are not infrequently to be found in lengths of chain. The safety of those who are employed where the chains are to be used must be provided for, but the uncertainties of the stress-withstanding properties of some ordinary chain make this at times rather difficult. Standards may be set up to ensure that the material and its many welds may not be unreasonably stressed, but a bad weld may not be discovered until collapse has taken place, and damage has been done. The members of the Institution of Mechanical Engineers who are present at the summer meeting may visit the works of Weldless Chains, Limited, at Gartsherrie, Coatbridge, and so have the opportunity of studying the production of chains by a method which has reduced almost to the elimination point the possibility of uncertainty in the stress resisting properties of chain links.

The weldless process of chain-making may be roughly described as the rolling of a length of chain, composed of many links, from solid metal in a special mill with four die wheel rolls. As will be appreciated, the designing of a rolling mill for such complex sections as those of a linked chain is a matter involving great difficulties, but the success obtained in the work and the results obtained from the chains produced are measures of the merits of the method. On this and the opposite pages, and on page 806, are illustrations of the rolling mill used and of some specimens of the chain produced. The machine was designed by Mr. A. G. Strathern, the inventor of the process, and constructed to his proposals by Messrs. D. Stewart and Co., Limited, of Glasgow. It is capable of rolling weldless chains with the diameter of the link metal up to 1½ in. Its general form and design is shown in Figs. 1 and 2, on this page, and in Figs. 12 to 15 on page 806.

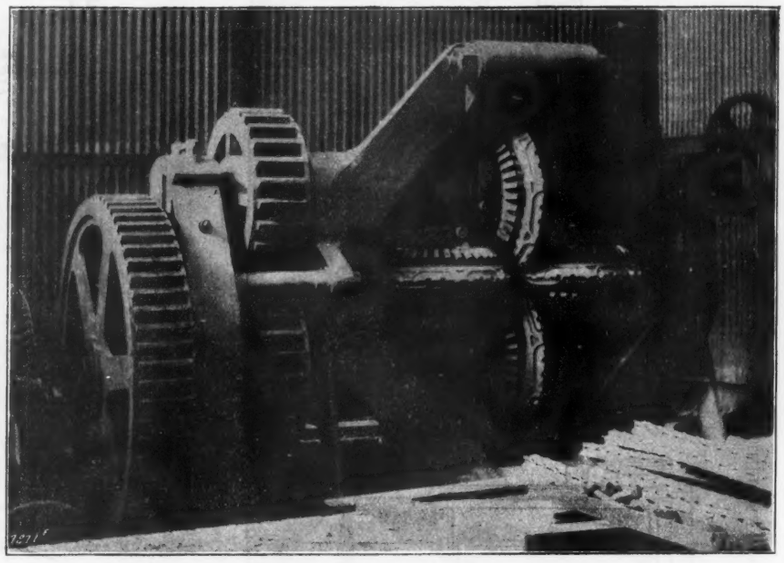


FIG. 1.

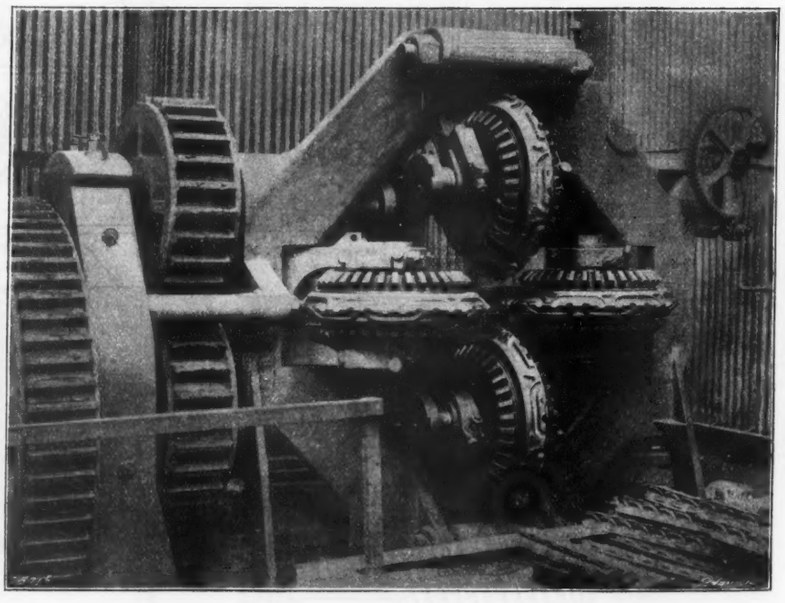


FIG. 2.

The frame is built up in halves and bolted together on the vertical centre line. On the inside are centred four double carrier arms, the detailed construction of

which is shown in Figs. 8 and 9. These provide support for the spindles on which the die wheels and their associated bevel wheels are mounted. The details of these wheels are shown in Figs. 10 and 11, from which it will be seen that each of these rotating systems consists of four components bolted and keyed together. The middle section is turned with a shoulder on its periphery at the one side to accommodate a corresponding groove on the inner face of the die. The two bevels are held tightly against the middle wheel by bolts of 1¼ in. diameter, and the shoulder on one of them serves to hold the die firmly in the required position. This construction permits the engagement of all the bevel wheels when working on the production of any size of the gear provided. For this, motion is given to the pinion shown on the right hand in Figs. 1 and 2. From the wheel it engages with, motion is given through a worm to a quadrant the other end of which gears with a toothed quadrant which is mounted on the shaft passing through the die carrier arms. The construction of the double quadrant is shown in Figs. 6 and 7, and it is also shown in place in Figs. 12 and 13. From one spindle the motion is carried through to the others by bevel toothed quadrants. Consequently when turning motion is given to the gear the bevel wheels and dies may be turned out of position.

The mill is driven by a 250-h.p. Peebles' electric motor through gearing providing a 94 to 1 reduction. Two horizontal shafts in the main frame have coupling plates at their ends for engagement

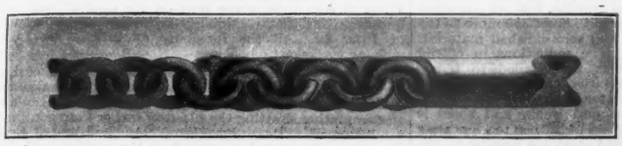


FIG. 3.

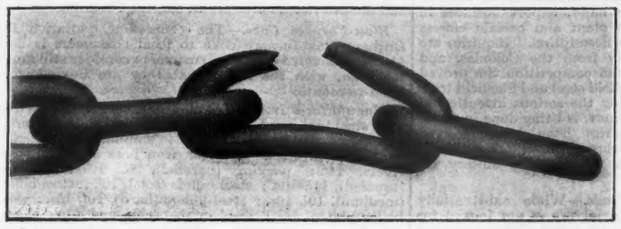


FIG. 4.

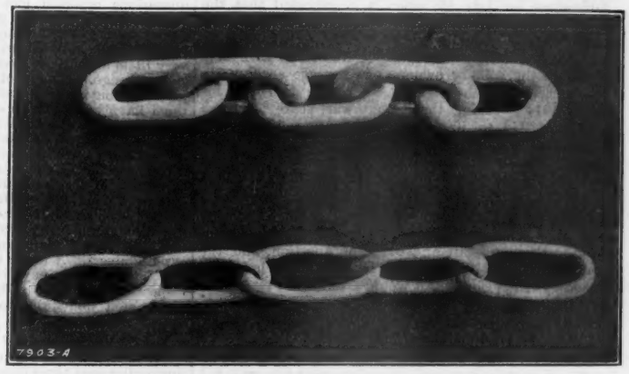
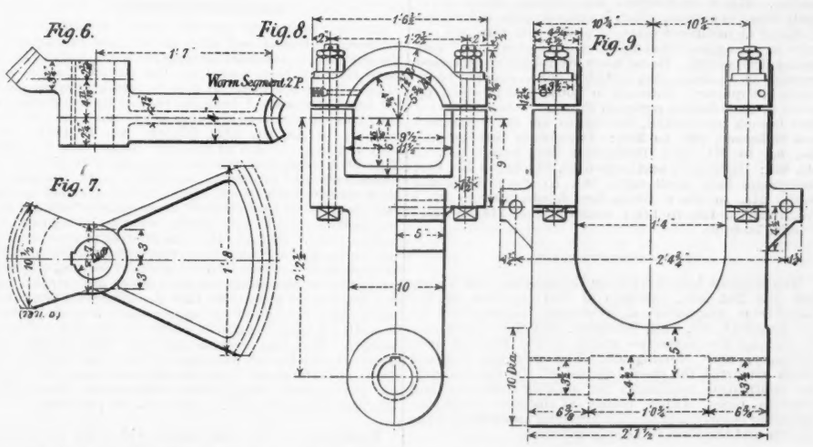
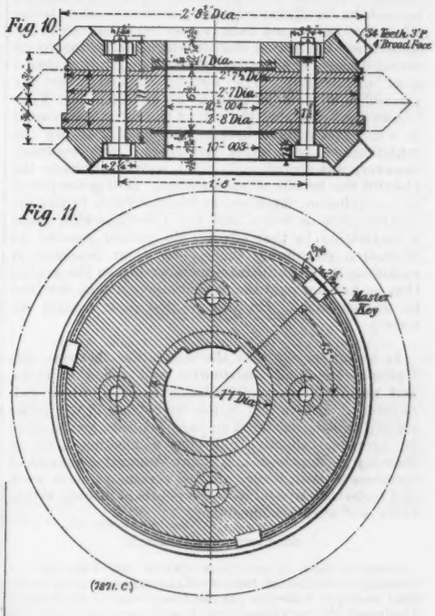


FIG. 5.





chain, and only the die rim is replaced when a change in the dimensions of the output is required.

For the cutting of the dies, Mr. Strathern had to design a special milling machine. In it the die rims are mounted at such a slope that the bevel edge to be worked is horizontal. The cutter is mounted on a lever system so that the grooves cut have the dimensions required and the shape is that of a standard. For this purpose two standard formers are used, the first of which is shaped to the curve of the top of the die rim so that the motion of the cutter along the rim face is restrained to the required curve. The second former has a standard shape of a link cut in it, and the travel of the cutter is controlled through its use to suit the exact requirements of motion along and across the rim face to provide the desired grooves to accommodate the links. When the arms on the feed system of the mill are set to the formers, reproductions of the grooves corresponding to the standard link can be made of any desired dimensions to suit the production of a die for any particular size of link. The alteration of the positions of the arms on the feed system changes the leverage and consequently the actual dimensions of the cut-out shapes on the die.

To facilitate the changing of the dies the double armed supports may be swung out of position as is shown in Fig. 2. In normal working positions the arms are bolted to the frame, and the coupling bolts on the horizontal shafts are in place. When these are removed the arms are free for turning out of position by with similar ones on the shafts of the die wheels at the top and bottom. The side die wheels obtain their drive through their bevel wheels from the other two. The bars are heated in a long furnace prior to rolling and are then passed into the rolls to be converted into chains.

Fig. 3 illustrates the stages in the production of the actual chain from the solid cruciform bar and shows how the material is pressed into shape in the rolls leaving a very thin face within and outside each link which is later broken away. After the rolling is completed the chain is annealed to recover the original properties of the steel from which it was produced. As an example of the nature of the loads the chain links will withstand, it may be stated that the chain links shown in Fig. 4 are those of a chain tested until one of the links broke. The load at which rupture took place was 9 tons 3 cwt., which may be compared with the Admiralty proof load of 2½ tons for this size, $\frac{7}{16}$ in., of chain. When we visited the works we were shown some of the proving house certificates of tests. Two may be cited, that of a $\frac{7}{8}$-in. weldless steel chain tested by Lloyds, broke with a load of 38·07 tons and of a 1-in. specimen which ruptured under a load of 50·5 tons.

Because of their strength these chains are much used where safety and durability are the essential requirements. In such service as the operation of tramway car brakes, as sling chains, colliery tub and railway wagon couplings, they are in increasing use in Britain and also abroad. One characteristic of the chain should be emphasised, and that is the provision of excess material at the ends of the links where wear usually occurs. The standard chains have these thickened ends, and they may work for years before wear brings the dimensions down to those with which an ordinary chain begins its life. In Fig. 5 there is shown an illustration of five links of a piece of ¾-in. weldless chain, and below it a similar chain after it had been in use for haulage work on a colliery for three years. The comparison is interesting as it shows the great advantage of making the links with thickened ends.

The excellent results obtained with weldless chains are undoubtedly due to the elimination of carelessly-made welds and the homogeneous character of the material throughout the link. If an exceptionally long chain is required two long lengths of weldless chain may be welded together. When such a course is necessary it is not open to the objections applying to ordinary chains, for there is but one weld, and that can be made with great care to ensure perfect solidity and strength. The process of chain-making introduced by Mr. Strathern is extraordinarily ingenious and possesses undeniable merits not the least of which is the elimination of weak links due to bad welding or faulty workmanship.

ANNUAL TABLES OF CONSTANTS.—Our attention is called to the fact that our reference to this publication, on page 681 *ante*, implies that the volume No. IV, in question was written solely by Mr. L. Descroix, director of the *Revue de Métallurgie*. Mr. Descroix contributed only the two sections, bound separately, which we received, covering Engineering and Metallurgy; the price of this section is 30 francs. The volume complete, No. IV which we did not receive, contains in all 1379 pages and deals with constants in all branches of physics, in magnetism, electricity, chemistry, &c., and its price is the one we indicated, namely, 210 francs in paper cover and 250 francs bound.

INDUSTRIAL NOTES.

THE motion for the second reading of the Adamson Coal Mines (Minimum Wage) Amendment Bill came up for discussion in Parliament last week. Its object was to amend the Coal Mines Minimum Wage Act of 1912, so as to provide a minimum wage for the workers in the mining industry equal to the increased cost of living to-day compared with the cost of living in July, 1914, and to extend the principle to the men who were excluded from the Act of 1912, namely, the colliery surface workmen. We have referred to the measure, and to the Wages Agreement now in force in previous issues. The division showed that there voted 154 for the second reading and 230 against, a majority of 76 against the second reading.

The Miners' Federation is to hold a conference at Folkestone on July 10, when it is expected that the whole subject of the miners' wages will come up for discussion. A meeting of the miners' executive is to take place on the previous day. According to figures given by the colliery owners, the average earnings in the present month are 153 compared with 100 for June, 1914; taking the 10 pre-war years they are now as 183·2 to 100. Under the wages agreement, which the Adamson Bill would have annulled, wages and profits should be divided in the proportion of 85 to 15. Last year the proportion was 93 to 7.

Conferences have been held between the employers and the executive of the Boilermakers' Society concerning the nightshift and overtime question, and the lock-out of the boilermakers; no statement has been issued by either side, but it would appear that no further conference has been decided upon and that the Boilermakers' Society is considering the advisability of taking a further ballot upon the matter in dispute.

A test trade union action was adjudged last Monday by Vice-Chancellor Lawrence, K.C., in the Lancashire Chancery Court. The plaintiff sought a declaration against the Amalgamated Society of Woodworkers to the effect that he was not liable to pay contributions to the society for the period during which, according to an earlier decision of the court, he was wrongfully excluded from membership. The society claimed from the plaintiff a sum of 15 guineas as arrears. The Vice-Chancellor found that the rule of the society amounted to a contract entered into by the plaintiff to pay the contributions and levies prescribed; this contract, however, was conditional on the society affording the plaintiff the benefit of membership. During the period of his exclusion, therefore, he was not liable to pay the contributions or levies, and the Vice-Chancellor made a declaration to that effect. He further granted an injunction restraining the society from expelling or excluding the plaintiff from membership on the ground that he had not paid the contributions during the time he was excluded. He also granted costs against the society.

It is announced that the difficulties between the National Union of Distributive and Allied Workers, and the Co-operative Wholesale Society, which culminated in strikes and in the boycotting of the latter society's goods, as stated on page 741 *ante*, are likely to be overcome shortly, following a meeting held on Tuesday in Manchester. A Joint Committee formed of members of both bodies ordered a resumption of work and undertook to deal with the points in dispute within 10 days of work recommencing.

SOCIETE DES INGENIEURS CIVILS DE FRANCE.—A meeting of the British Section of this Institution is to be held to-day at 8.30 p.m., at the Institution of Mechanical Engineers, Storey's Gate, S.W. 1, when a paper illustrated by lantern slides will be read by Mr. M. Barrillon, Ingénieur en Chef des Ponts et Chaussées, on the Port of Rouen and the Lower Seine. Members of the Institution of Naval Architects are invited to attend.

INTERNAL-COMBUSTION ENGINE CAMS.—The following typographical errors appeared in the above article, which was published in the issue dated May 25, 1923. Some of these corrections were made on page 760 of our issue of June 15, and others, since notified to us, are here included in order that the article may be made perfectly clear:

Page 641, line 15, "to" should read "or."

Page 642, column 2, line 5, should read—

$$f \sin \psi = d \sin (\theta_2 - \theta).$$

Page 642, column 2, line 8 should read—

$$\cos \psi = \frac{1}{f} \left\{ f^2 - d^2 \sin^2 (\theta_2 - \theta) \right\}^{\frac{1}{2}}$$

Page 643, column 1—the value of the acceleration given by equation (12) should be—

$$= \left(\frac{d\theta}{dt}\right)^2 \left[a \cos\theta - \frac{a^2 \{a^2 \sin^4\theta + b^2 \cos 2\theta\}}{\{b^2 - a^2 \sin^2\theta\}^{\frac{3}{2}}} \right] \quad (12)$$

The second limit stated in the next line should be θ_1.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The developments of the past fortnight have induced many of those engaged in the heavy trades to take a somewhat less cheerful view of the immediate position and of the outlook, but, after allowing for reaction in certain branches where recent expansion was due entirely to abnormal causes, the general trend of business seems to be slowly and steadily on the upgrade. Expansion of output and the provision of wider facilities for production are progressing, despite the current cash scarcity and a difficulty in obtaining new business on reasonably remunerative terms. A notable feature is the extension of local colliery workings and the growth of colliery villages in the South Yorkshire neighbourhood. One concern has put up 200 additional houses during the past twelve months, has got out plans for a further 350 and is prepared to erect 350 more as the scheme progresses. In raw and semi-finished materials business is uniformly dull. The reductions in official quotations reported last week have failed to tempt buyers. Except under unexpired contracts deliveries are confined to small tonnages for immediate use. Steel-making irons are featureless and weak, and there is very little activity in steel scrap at 1*l.* per ton less than a month ago. Makers of mild steel are getting to the end of the big business booked earlier in the year. Few of them have been able to extend their order books on a satisfactory basis, and there is every prospect that in this section the output for the next month or so will have to be curtailed. On the other hand, export business in heavy machinery, industrial plant and certain classes of tools is of a more healthy description. Inquiries are coming to hand more freely from the Colonies, and despite the bogey of American competition the proved quality and reliability of Sheffield steel and Sheffield tools and implements are attracting the serious attention of export buyers. A wider business is being done in stainless materials. Many inquiries have been received respecting the new nickel-chromium alloy, which is guaranteed non-stainable in the form of cutlery for domestic use.

South Yorkshire Coal Trade.—While substantially cheaper fuel for home industrial use is not looked for during the next three months, the effect of the recent fall in business with the Continent is reflected in a reduction this week of 6*d.* per ton in Yorkshire best steam hards, and 1*s.* 6*d.* per ton in Derbyshire steams of similar quality. Home contractors are coming rather more freely into the market, which is absorbing the full output of slacks at unaltered rates. Cobbles and nuts are not quite so strong as a week ago, Derbyshire best small nuts having declined 6*d.* Home users are taking an increased tonnage of furnace and foundry coke, exports being somewhat quieter. Business in house coal is about up to the average for this period of the year. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 18*s.* to 20*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 12*s.* to 14*s.*; nutty slacks, 11*s.* to 13*s.*; Smalls, 7*s.* to 9*s.*

MANCHESTER ASSOCIATION OF ENGINEERS.—On Thursday, the 21st inst., upwards of 100 members of the Manchester Association of Engineers, accompanied by the president, Mr. Cecil Bentham, had the opportunity of viewing the extensive works of the Stanton Iron Company, near Nottingham. The principal features which attracted the special notice of the visitors were the centrifugal appliances for making cast-iron and concrete pipes. Other points of interest were the annealing plant, the automatic charging apparatus for the cupolas and the blast-furnace installation.

THE BIRMINGHAM METALLURGICAL SOCIETY.—The April issue of the Journal of this society contains a 33-page essay on the "Formation and Functions of Blast Furnace Slags," by Mr. Arthur Knight, Stoke-on-Trent, which was awarded the society's bronze medal and prize. It also gives a short paper by Dr. J. Newton Friend, dealing with "Recent Progress in the Study of Corrosion." Copies of the issue are still available and may be obtained for 1*s.* each, post paid, on application to the Secretary, Chamber of Commerce Buildings, New-street, Birmingham.

DIE-CASTING RESEARCH.—The British Non-Ferrous Metals Research Association has undertaken an extensive series of investigations on Die Casting Alloys, which will spread over at least three years, and entail an expenditure exceeding 10,000*l.* Full particulars of the scheme can be obtained from the associations headquarters, 71, Temple-row, Birmingham. Various types of alloys are used in die casting; the research has been divided into three sections: (1) Brass and bronze alloys; (2) aluminium alloys; (3) low melting-point alloys (zinc, tin, lead, &c.). These three branches, with suitable arrangements for co-operation, will be dealt with in separate institutions, under the supervision of recognised leaders of metallurgical research. Every care is being taken in the constitution of the committee which controls the work, to ensure that both the manufacturers and the users are represented. Work of this nature demands the close interest of the industry, and it is hoped that no difficulty will be experienced in obtaining the small subscriptions required to assure the substantial Government support, which is only available in a measure dependent on the backing of the scheme by the industry.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is next to nothing doing in Cleveland pig-iron. Buyers are ordering to meet early essential needs only, and values show further marked downward tendency. Producers complain that market rates are unremunerative and are reluctant to make further price concessions, especially as there seems little likelihood of any early material fall in cost of output. Under such circumstances it is not surprising to hear hints of possibility of putting blast furnaces out of operation. No. 1 Cleveland pig-iron is extremely scarce, and is quoted 125*s.* to 126*s.* No. 3 g.m.b. is obtainable at 112*s.* 6*d.*, and, indeed, that figure might be shaded. Foundry 4 is very plentiful, and is offered freely at 110*s.* There is not much forge iron on the market, and the quotation for that commodity is in the neighbourhood of 107*s.* 6*d.* All the foregoing quotations are f.o.t. makers' works or f.o.b. Tees.

Hematite.—Unsatisfactory accounts are given of the hematite trade. Stocks are accumulating and sales are difficult to arrange. Makers in this branch also are contemplating shutting the blast off rather than continue producing at a loss. Parcels of Nos. 1, 2 and 3 East Coast brands are being pressed on the market both for home purposes and for shipment to destinations abroad.

Foreign Ore.—There is absolutely nothing doing in imported ore. Nominally best rubio is 24*s.* c.i.f. Tees, and Mediterranean ores are in the neighbourhood of 23*s.*

Blast-Furnace Coke.—The concession quotation for Durham blast-furnace coke to local consumers is now 41*s.* 6*d.* delivered—a figure customers consider still much too high, with the result that they are buying from hand-to-mouth.

Manufactured Iron and Steel.—Markets for finished iron and steel are very difficult to discover. Bar iron is extremely slow of sale, as is also shipbuilding material, and re-rolled steel. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 10*l.*; steel billets (medium), 10*l.* 10*s.*; steel billets (hard), 10*l.* 15*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; heavy sections of steel rails, 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 13*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 18*l.* 10*s.*

BRITISH STANDARD ROLLED STEEL SECTIONS.—The moments of inertia and other geometrical properties of the new British standard sections (issued in August, 1920) have recently been issued by the British Engineering Standards Association. It may be recalled that to meet the urgent requests of designers the association published the figures in regard to channels and beams as an advance measure in August, 1921 (Report No. 4—1921), and they are incorporated in the new Report No. 6—1923. This is divided into two portions, the first giving the dimensions and properties in British units, the second their metric equivalents, attention being called to the fact that in the case of small discrepancies between the two portions the British measures are to be regarded as the standard. So far as the data relating to equal angles, unequal angles and tee bars is concerned, for which there is more than one standard thickness of section, only the properties of the minimum thicknesses are printed, but the association announces that the values for the other thicknesses calculated by approximate formulæ, which it is also intended to publish, will be issued in a subsequent edition. The new report, entitled "Dimensions and Properties of British Standard Rolled Steel Sections for Structural Purposes," may be obtained from the offices of the British Engineering Standards Association, 28, Victoria-street, S.W. 1, price 1*s.* 3*d.* post free.

PERMALLOY.—The permalloys which H. D. Arnold and G. W. Elman, of the Western Electric Company, are studying, are nickel-iron alloys of remarkable magnetic properties. It was well known that the initial magnetic permeability of nickel-iron increased to about $\mu = 2{,}000$, as the nickel percentage was raised to 30 per cent. and 40 per cent. When the nickel percentage was raised from 60 to 80, however, they found a further very steep rise in the μ, to 12,000 and more; with still higher Ni percentages the permeability drops off abruptly. The absolute values depend much on conditions; in some cases permalloy was 30 times as permeable as soft iron. Although this very high permeability goes together with a very low saturation—the saturation value being practically obtained already in the magnetic field of the Earth—the property is of great technical importance for telegraph and telephone work and submarine cable operation. From this point of view and for theoretical reasons a further study of these properties [see Journal of the Franklin Institute, May] is very desirable. The 80 per cent. Ni alloy which gives the peculiar high magnetic peak is not distinguished by other special properties. As soon as the nickel percentage exceeds 30, the iron-nickel alloy assumes the crystallographic character, the face-centred cube, of nickel, no longer showing the body-centred cube of iron. The permalloy is magnetically spoiled by the presence of carbon; thermal treatment is of little importance, provided the cooling between 900 deg. C. and 300 deg. be slow. The permeability of permalloy is so sensitive to strain that almost any magnetic value can be imparted to specimens by suitable mechanical stress. Magnetised permalloy loses 2 per cent. of its electric conductivity per gauss. The manifold peculiarities should be valuable in the study of the nature of magnetism. Dr. Rosenhain referred to this alloy at the last meeting of the Iron and Steel Institute, as we reported on page 646 *ante*.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions of a very unsatisfactory nature continue to prevail in the steel trade of Scotland, and there would seem to be little hope of a betterment in the near future. The sum total of new business booked over the week so far as can be ascertained is very small indeed and will not have much effect on the plant now running. A want of confidence in the general trade position has much to do with the present slackness, and few have any inclination to launch out on new projects so long as world conditions remain so uncertain, and this district, which had always such a large overseas trade is now feeling the pinch very badly. The annual Fair Holidays are due in a fortnight, but the date of reopening the works depends on circumstances. Inquiries are poor and plate mills are suffering from the lock-out of the boiler-makers, with the result that shipbuilders are requisitioning practically almost nothing at all. Structural sections show a falling-off and black sheet makers report very little fresh business, while the general export trade all round is exceedingly quiet. Prices show no change and are as follow: Boiler plates, 13*l.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{1}{16}$ in. to $\frac{1}{4}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The state of the West of Scotland malleable iron trade is very similar to the steel trade. Inquiries are few, and orders being given out consist mainly of the immediate requirements of consumers, so that managements cannot see any distance ahead. Prices are unchanged with "Crown" bars at 12*l.* 10*s.* per ton, delivered Glasgow. stations.

Scottish Pig-Iron Trade.—A quiet tone characterises the Scottish pig-iron trade this week, and only a moderate amount of dealing has taken place. Hematite continues in very poor demand and deliveries are small. Foundry grades for home consumption are rather dull and export business is stiff. Prices are inclined to be easier and the following are current quotations:—Hematite, 5*l.* 17*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 15*s.* per ton, and No. 3, 5*l.* 10*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, June 23, only amounted to 637 tons. Of the total 557 tons went overseas and 80 tons coastwise. For the corresponding week last year the figures were 1,593 tons overseas and 144 tons coastwise, making a total of 1,737 tons.

Shipbuilding.—The Caledon Shipbuilding and Engineering Company, Dundee, have just secured an order for a vessel of 8,000 tons for propulsion by internal combustion engines. This vessel is for Messrs. James Chambers and Co., Liverpool.

PERSONAL.—Mr. Roland Dunkerley, chief works accountant of the Metropolitan Vickers Electrical Company, Limited, Old Trafford, Manchester, has been elected chairman of the council of the Institute of Cost and Works Accountants, London, for the ensuing year.—The Brown Hoisting Machinery Company, Cleveland, Ohio, U.S.A., are opening, on July 1, a direct factory branch in London (25, Victoria-street, S.W.), to "handle" a complete line of all their well-known crane, loading, unloading, bucket and other handling plant.—The Association of Consulting Engineers have selected Mr. J. Mitchell Moncrieff, C.B.E., M.Inst.C.E., M.Amer.Soc.C.E., as chairman for the ensuing year.—The United Steel Companies, Limited, Sheffield, will, on July 6 remove their London office from 15, Victoria-street, Westminster, S.W. 1, to St. Stephen's House, Victoria Embankment, Westminster, S.W. 1.—Mr. Frank H. Brunt, M.Inst.C.E., has removed from 121, Victoria-street, to 17, Victoria-street, S.W. (telephone Victoria 8477).

FURNACES FOR BURNING POWDERED COAL.—Furnaces in which powdered coal is to burn must be large enough, and be correctly shaped, so that the coal may burn completely without impinging on the brickwork, and must be provided with facilities for removing the ash, states Bulletin No. 217, just published by the United States Bureau of Mines. If the furnace is correctly designed, about 3 B.Th.U. per second may be liberated per cubic foot of combustion space. This rate of combustion is sometimes exceeded, but if it is much exceeded the coal will not be burned completely. In many furnaces the temperature is so high that the ash fuses, and on settling in the furnace collects in a continuous mass. It has been found expedient in some furnaces to provide means so as to prevent the collection of the ash in a continuous mass, though generally this is not done, and the ash collects either on the hearth, whence it is removed when the furnace shuts down, or it is removed as a liquid slag. The ash that does not settle in the furnace goes off with the gases, and care must be taken to see that it is not deposited in the flues and so impede the draught. When a furnace previously heated by coal burned on a grate, by gas, or by oil, is to be transformed into a powdered-coal fired furnace, the furnace may, or may not, have to be modified in design to suit powdered coal. Except for boiler furnaces, very radical alteration of design is unusual. At most, the change consists usually in enlarging the furnace. But no furnace should be fired with powdered coal without the advice of experienced engineers, who will either approve the application of powdered coal to the furnace as it exists or carefully re-design it so that it may be economically operated with powdered coal, using the best means of disposing of the ash.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—According to the official returns of the Board of Trade more coal was exported from South Wales in May than in any previous month of the year. The value of the shipments, too, established a record for the year, as also did the average f.o.b. price per ton. This result was achieved despite the fact that work was suspended at the docks for two days and at the collieries for three days in view of the Whitsun holidays, and the consequent reduction in the number of working days during the month. Shipments in May totalled 2,757,583 tons, compared with 2,474,321 tons in April and the value amounted to 3,913,679*l.* against 3,308,313*l.* while the average f.o.b. export price per ton was 28*s.* 4*d.* compared with 26*s.* 9*d.* The volume and value of shipments, together with the average realised price per ton, is shown below:—

1923.	Quantity. Tons.	Value. £	F.o.b. Average Per Ton. s. d.
January ...	2,398,248	2,803,274	23 4
February ...	2,275,794	2,762,125	24 3
March ...	2,697,788	3,351,965	24 10
April	2,474,321	3,308,313	26 9
May	2,757,583	3,913,679	28 4

Compared with April the volume of shipments in May showed an increase of 283,000 tons and with January of 359,000 tons, while the value was 605,000*l.* greater than in April and 1,110,000*l.* more than in January. The average f.o.b. price was 1*s.* 7*d.* per ton above that of April and 5*s.* more than in January. All classes of coal with the exception of anthracite small shared in the improvement. The curve of average prices in respect to steam coal shifted from Cardiff and Swansea is shown below:—

1923.	Cardiff. Small. s. d.	Thro'. s. d.	Large. s. d.	Swansea. Small. s. d.	Thro'. s. d.	Large. s. d.
January	16 6	20 0	26 9	17 0	18 11	26 9
February	17 8	21 5	27 1	16 2	18 7	26 5
March ...	18 11	24 6	28 0	17 11	19 5	25 0
April ...	21 2	25 6	29 10	19 11	21 6	25 6
May ...	23 0	27 10	31 4	20 10	22 2	28 11

Anthracite small in May averaged 21*s.* 9*d.*, compared with 22*s.* 7*d.* in April and large 40*s.* against 37*s.* 5*d.*

Dock Charges Reduced.—The Great Western Railway Company, the owners of the South Wales Docks, have decided to reduce dock charges, tonnage dues, wharfage and crainage rates from 75 per cent. to 60 per cent. above the pre-war rates, and tipping and weighing charges from 8*d.* to 7$\frac{1}{2}$*d.* per ton; the reductions to take effect from July 1.

ELECTRIC FURNACE DETINNING AND PRODUCTION OF IRON FROM TIN-PLATE SCRAP.—In the past practically all the use that has been made of discarded tin cans, so far as the recovery of their iron content is concerned, has been to melt them up in a cupola and cast the resultant metal into such objects as sash weights, &c., the resultant metal not being suited for making sound cast-iron castings, such as are made from ordinary pig-iron, as the iron was too brittle to be serviceable. Experiments have been conducted in an electric furnace by the Department of the Interior at the Bureau of Mines experiment station at Seattle, Wash., in which tin-plate scrap was melted with various additional agents. Sodium chloride, iron sulphide and an oxidising slag were tried, but the conclusions reached were that in the electric furnace complete detinning is impossible and any detinning impractical. Melting tests conducted in the cupola showed that the amount of detinning was dependent upon the amount of surface of metallic tin exposed to the oxidising gases, and will be somewhere between the limits of 0 per cent. and 50 per cent. Test bars, prepared by melting pig-iron with various quantities of tin, were subjected to physical tests. The results showed that a tin content of 1 per cent. or less did not seriously affect the properties of grey iron. Synthetic cast-iron made from tin-plate scrap was used successfully in making commercial castings of good quality.

THE EXPLOSION OF THE SWISS NITRUMWERKE AT BODIO.—The explosion, in July, 1921, of the Nitrumwerke at Bodio, in the Canton of Tessin, which killed 14 men and injured a great many others, seems to have had a chemical cause, though the result of the official inquiry has not yet been published, owing to disagreement of the foreign experts consulted. The question is of interest because the mixture of nitrogen tetroxide and benzene, to which the explosion was no doubt due, has found various applications and was utilised in bombs during the war. Turpin recommended the mixture in 1883 as being relatively safe, as only to be exploded by strong percussion or by detonators. In the nitric acid works at Bodio, steel coils carrying nitrogen tetroxide had become leaky so that the tetroxide mixed with the cooling agent, benzene. The mixture would have been discharged into the River Tessin, but the water level in the river was very low at the time. It was hence decided to separate the tetroxide from the benzene by distillation below 70 deg. C. Half of a total of the 6 tons of mixture had been distilled, when the cold mixture in a tank was noticed to heat spontaneously. External cooling by means of water was attempted when the explosion took place. Subsequent experiments proved that the distillation as such is safe; but the great heat of that summer seems to have been responsible both for the corrosion by the tetroxide of the steel tubes and for some slow reactions causing the spontaneous heating.

NOTICE OF MEETING.

THE INTERNATIONAL NAVIGATION CONGRESS.—Monday, July 2, to Wednesday, July 11, at the Institution of Civil Engineers, Great George-street, S.W. 1. Monday, July 2, at 12 noon: Formal Opening of the Congress by Lord Desborough, K.C.V.O. At 3 p.m.: First Section, Inland Navigation. In Great Hall, discussion of Question No. 1, "The Utilisation of Waterways for the Production of Power; its Consequences and Applications. Second Section, Ocean Navigation, Lecture Theatre, at 3 p.m.: Discussion of Questions Nos. 1 and 2, (1) "The Accommodation to be Provided for Ships in Connection with the Construction of New Works at Ports in Order to Satisfy the Future Dimensions of Ships"; (2) "Types of Works for Berthing Ships of Great Draught in Tidal Seas." Tuesday, July 3, at 10 a.m.: First Section, Inland Navigation. In Great Hall. Discussion continued of Question No. 1. At 2.30 p.m.: Discussion of Question No. 2, "Dispositions or Arrangements to be adopted for Locks, Elevators, Inclined Planers, and other Means of Overcoming Differences of Level with a View to Facilitating the Operations." Second Section, Ocean Navigation. Lecture Theatre, at 10 a.m.: Discussion continued of Questions Nos. 1 and 2. At 2.30 p.m.: Resumption of discussion Wednesday, July 4, at 10 a.m.: First Section, Inland Navigation. In Great Hall. Discussion of Question No. 2. Second Section, Ocean Navigation. Lecture Theatre. Discussion of Question No. 3, "The Relative Advantages of Ship Equipment and Port Equipment for Loading and Discharging Ships, Mechanical Equipment of Ports, Mechanical Handling of Freight, Loading, Discharging and carrying between Ships and the Various Depositing Points, whether Covered by Sheds or not." Thursday, July 5, at 10 a.m.: First Section, Inland Navigation. In Great Hall. Discussion of Communication No. 1, "The Influence of Surface Waters and Subterranean Sheets of Water on the Flow of Rivers, Régime of Mixed Canals; Estimation of the Water Consumed for Navigation and Irrigation Uses; the Portion Returned to the Subterranean Sheet of Water." at 2.30: Discussion of Communication No. 2, "Unification of Statistics of Inland Navigations with a View to Facilitating the Comparison of the Results of the Working of Navigable Waterways in Various Countries." Second Section, Ocean Navigation. Lecture Theatre, at 10 p.m.: Discussion of Question No. 3 continued. At 2.30 p.m.: Discussion of Communications Nos. 1 and 2, (1) "Concrete and Reinforced Concrete, their Applications to Hydraulic Works; Means to Insure their Preservation and their watertightness"; (2) "Use of Liquid Fuel for Navigation and its Consequences." 4 p.m. to 6 p.m.: Reception by the Lord Mayor of London. Friday, July 6, at 10 a.m.: Ocean Navigation Section. Lecture Theatre. Discussion of Communications Nos. 3 and 4., (3) "Utilisation of Tides for the Production for the Working and Lighting of Ports and for Maritime Works (Working of Lock Gates, &c.)"; (4) "Principle Advances made Recently in Lighting, Beaconing and Signalling of Coasts; Standardisation (Unification) of the Languages of Maritime Signals." At 2.30 p.m.: In Great Hall. General Meeting of the Congress. Close of the discussions of the Congress. Saturday, July 7,: Visits and excursions. Monday, July 9: Visits to Various Ports and Harbour Works. Tuesday, July 10: Visits to South Wales and Manchester. Wednesday, July 11; Visits to Bristol and Liverpool.

INSECTS BORING THROUGH THE LEAD SHEATHS OF CABLES.—The United States Bureau of Entymology (Bulletin 1,107) is inquiring into the damage done to telephone cables in California by a small beetle, which bores a hole through the lead sheath, but does not attack the rubber. The holes, about 0·1 in. in diameter, admit moisture to the cable; the beetle does not appear to mind the lead, nor other poisons, but it is repelled by beef tallow, in which it appears to be suffocated. This fact was discovered, because the attack is generally made from the steel rings, by which the cables are suspended; when these rings are greased with tallow, the cables are not attacked.

THE GERMAN MACHINE INDUSTRY.—The report of the Union of German Machinery Manufacturers for the year 1922 contains several particulars of interest. The import of foreign machinery had dwindled down to a nominal fraction of the exports, about 2 per cent., the figures being respectively 10,700 tons and 491,000 tons, the German manufacturers now being able to almost entirely cover the home requirements. Still the machinery industry had had great difficulties to contend against. The 8-hour day and trouble concerning overtime, insufficient supply of iron, the fall of the exchange, increasing wages, shortage of skilled labour, the different taxation laws, the weakening of inland capital, import difficulties, &c., all had made themselves felt. The number of orders had receded on an increasing scale in the course of 1922. With reference to output in weight per man the union states that for 1922 it was on the average less than half the pre-war figure. The weight of products per man averaged, in 1910, 6·9 tons; in 1911, 6·9 tons; in 1912, 7·4 tons; in 1913, 7·7 tons; in 1921 the figure had receded to 4 tons; and in 1922, to 3·9 tons. The supply of pig-iron and rolled iron was inadequate during 1922. The industries employing pig-iron received only about 30 per cent. of their requirements. There was a continuous shortage of bar iron and sheets, but a sufficiency of heavy plates. Serious complaints had been made with regard to the price of pig-iron, especially after the rise of 50 per cent. on August 1, 1922.

ROLLING MILL FOR THE PRODUCTION OF WELDLESS CHAINS.

(For Description, see Page 802).

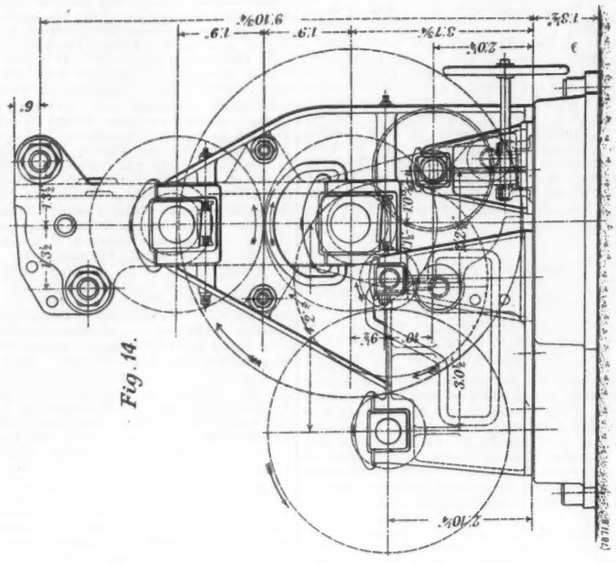


Fig. 14.

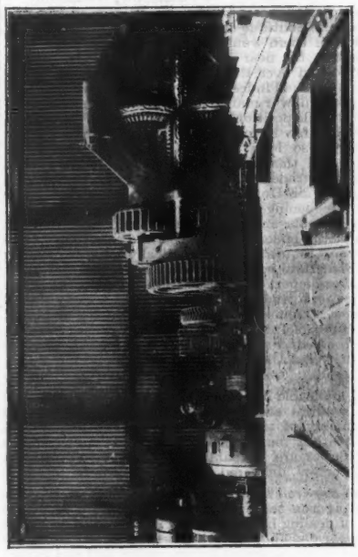


Fig. 15.

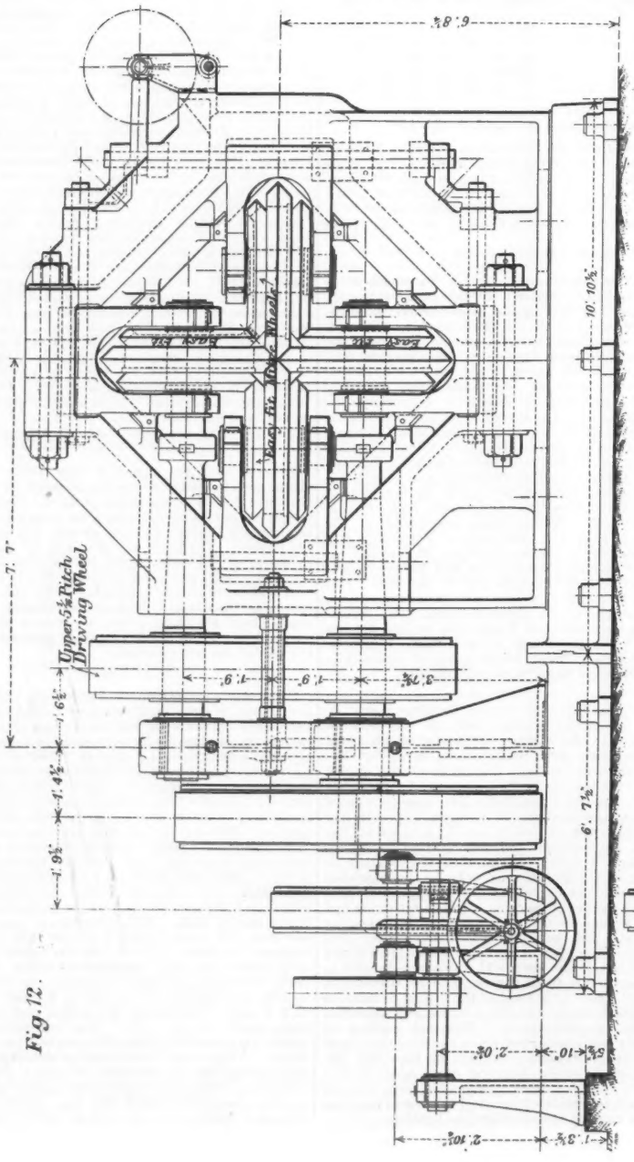


Fig. 12.

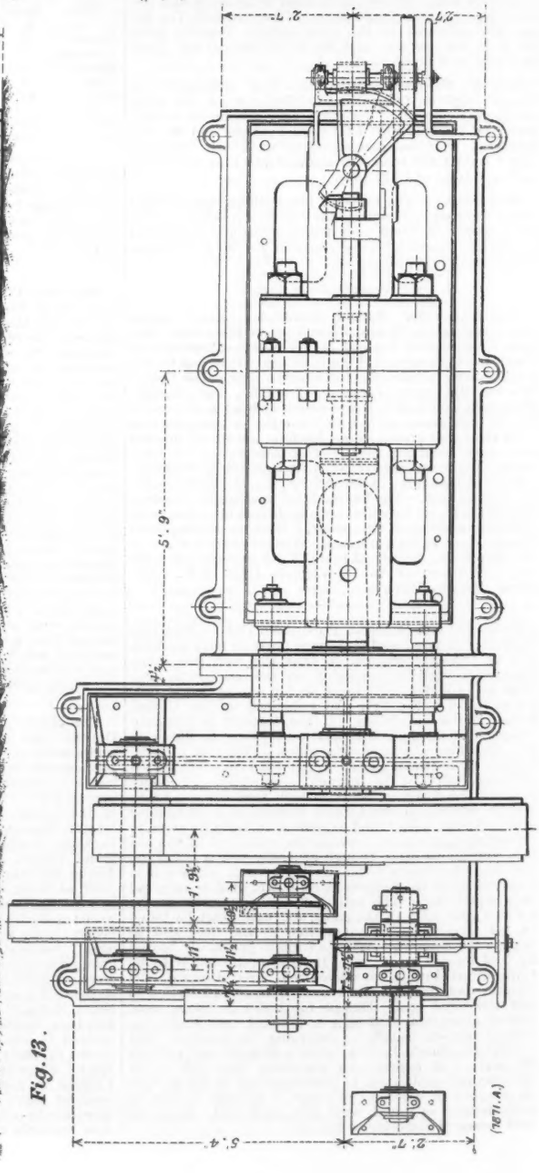


Fig. 13.

TAR STILLS WITH PREHEATERS AND CONDENSERS AT THE PROVAN CHEMICAL WORKS, GLASGOW.

(For Description, see Page 792.)

Fig. 18.

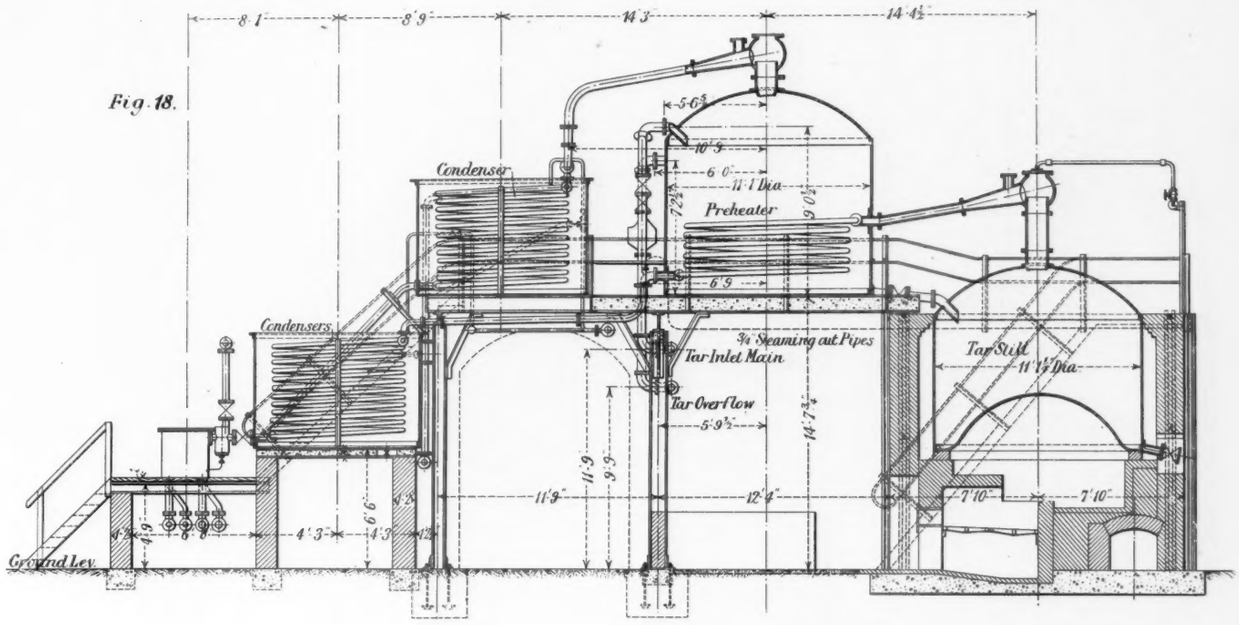
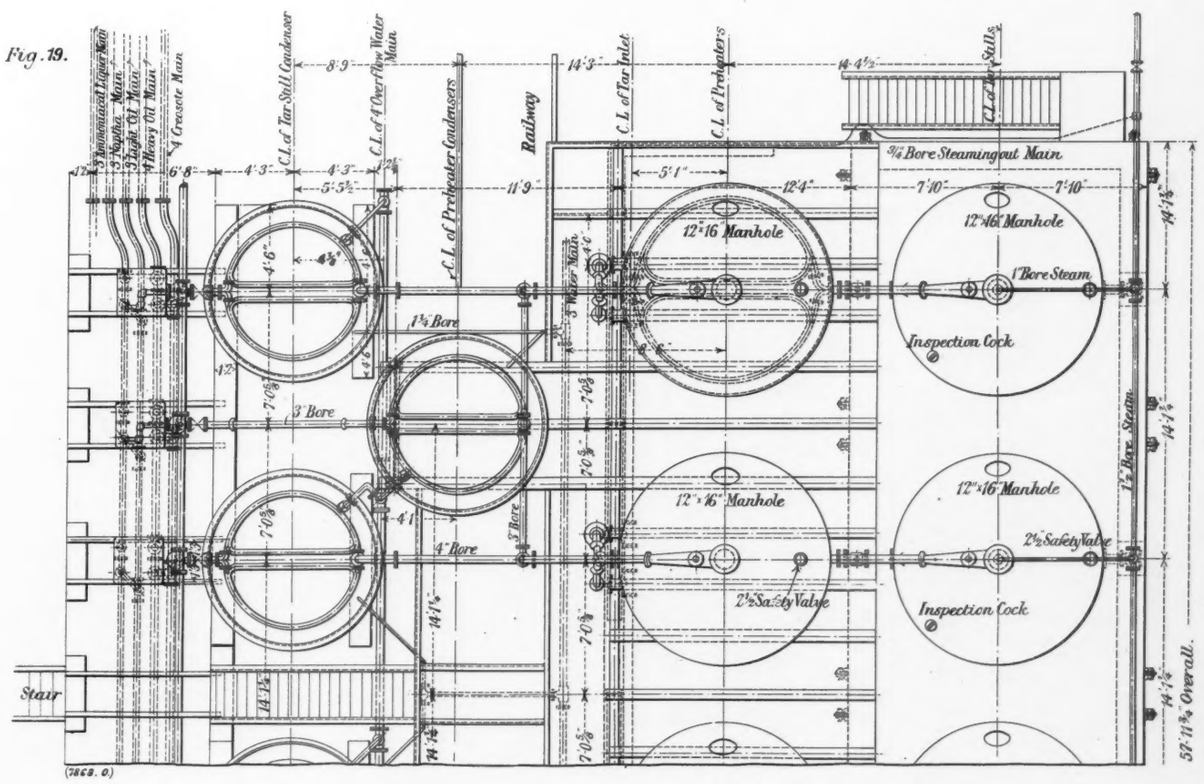


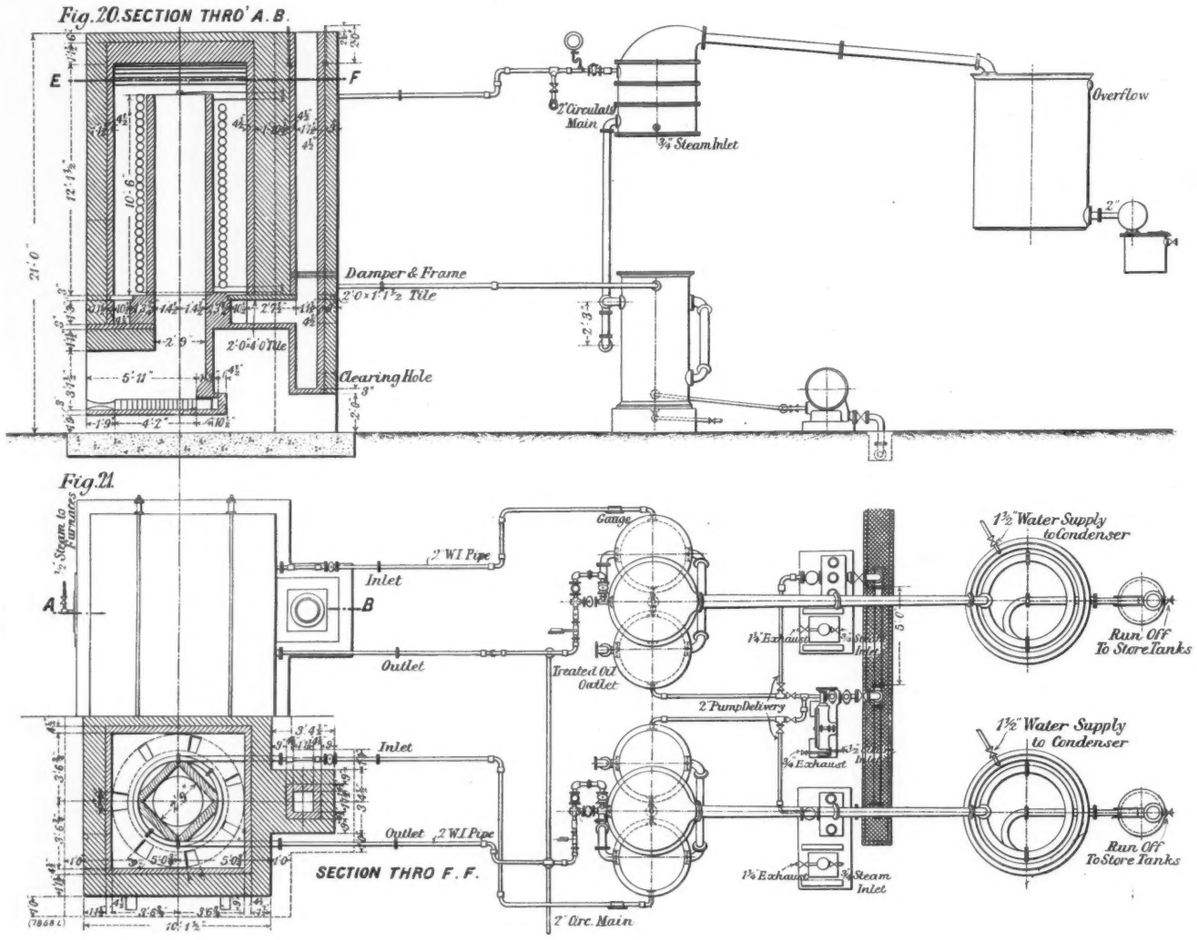
Fig. 19.



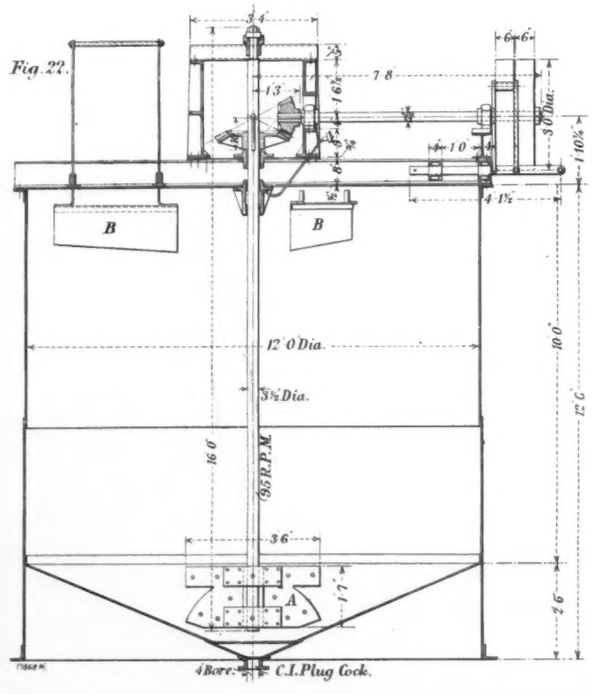
(To face page 792.)

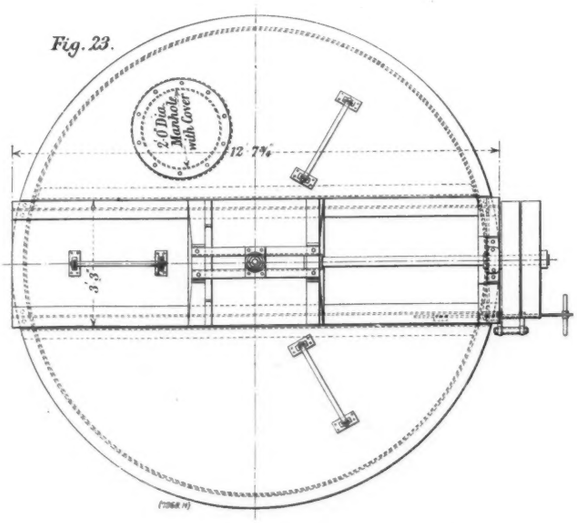
THE PROVAN CHEMICAL WORKS, GLASGOW.

(For Description, see Page 792.)



FIGS. 20 AND 21. "WILTON COIL" FOR TAR DISTILLATION OR NAPHTHA STRIPPING.





FIGS. 22 AND 23. OIL WASHING PLANT.

TWO-STROKE DOUBLE-ACTING DIESEL ENGINE.

CONSTRUCTED BY THE NORTH BRITISH DIESEL ENGINE COMPANY, LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 794.)

Fig. 1.

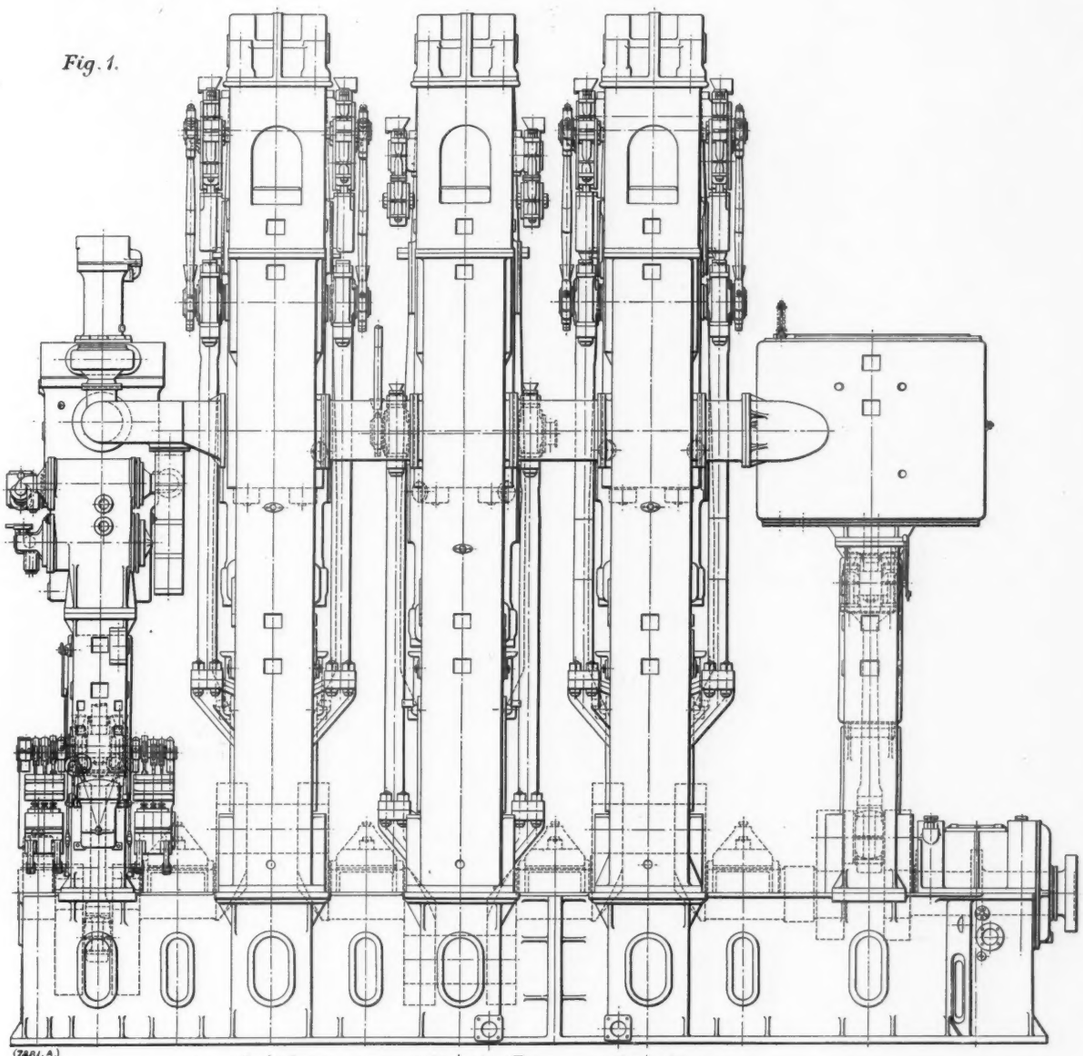


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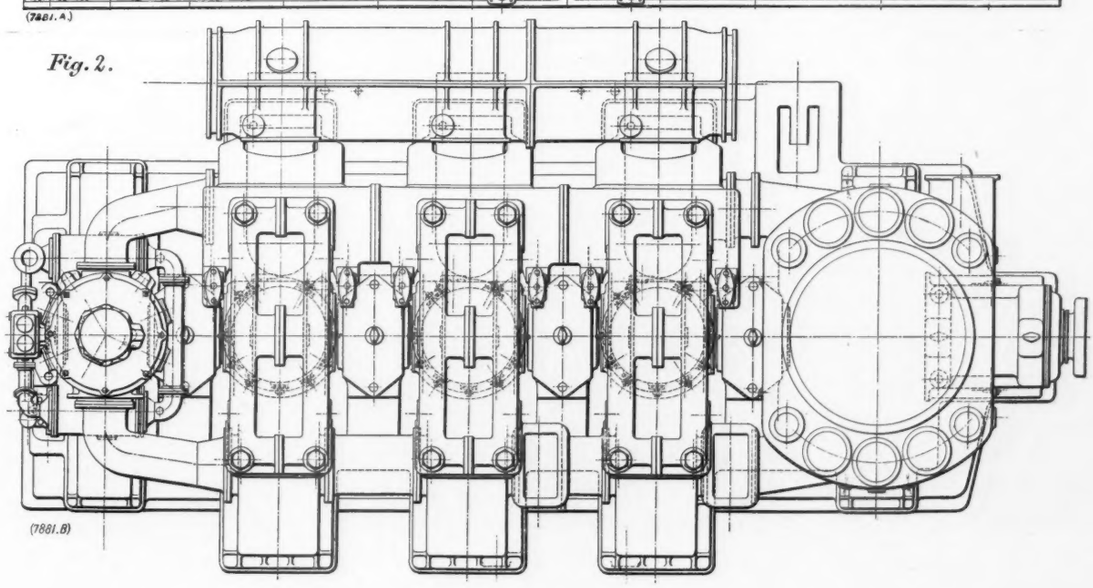
Fig. 2.



(7881.B)

TWO-STROKE DOUBLE-ACTING DIESEL ENGINE.

CONSTRUCTED BY THE NORTH BRITISH DIESEL ENGINE COMPANY, LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 794.)

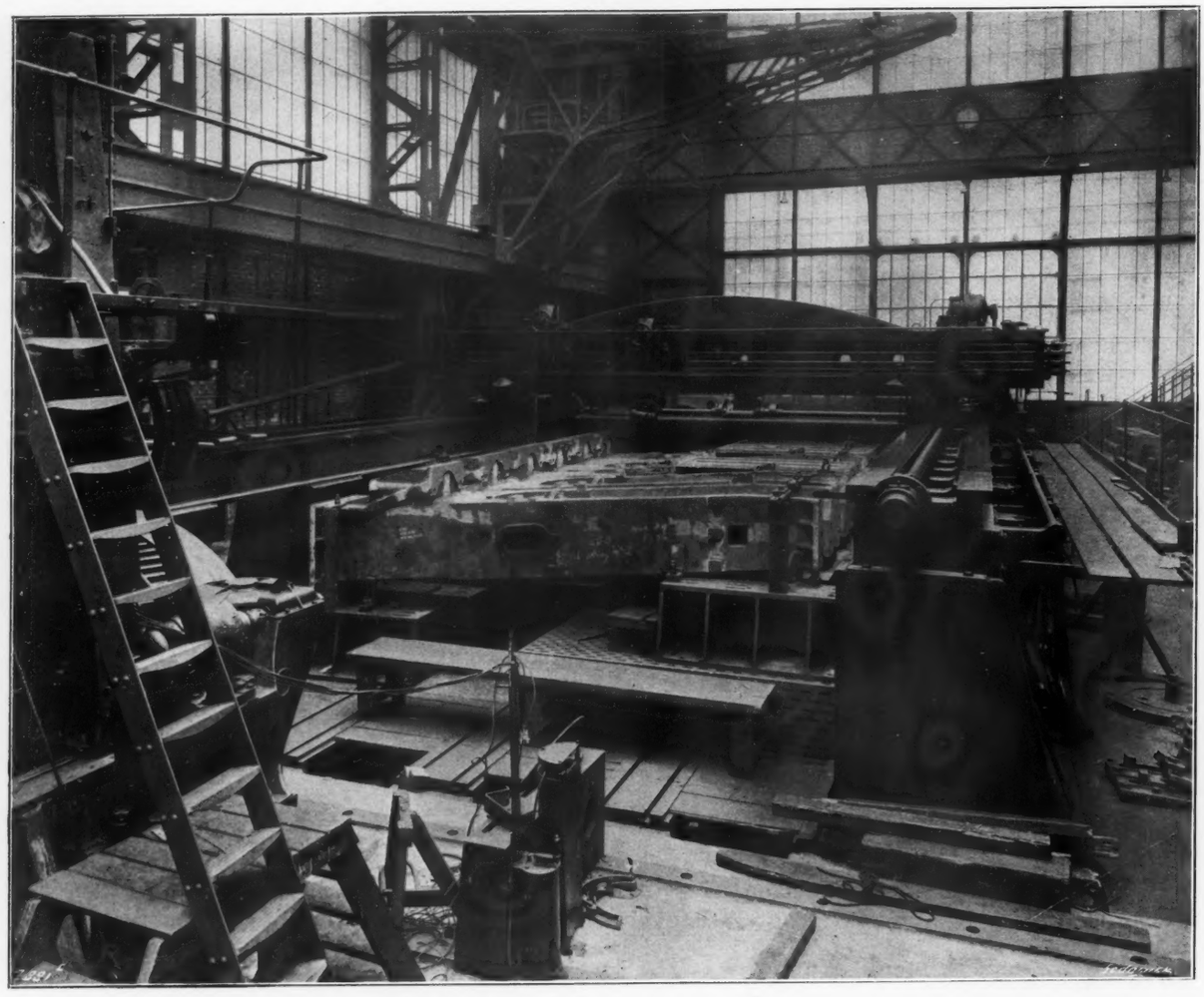


FIG. 3. MACHINING THE SIDE COLUMNS.

FIG. 4. CYLINDER COVERS AND CYLINDER LINER.

(*To face page* 795.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

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Two One-Page Plates.—TWO-STROKE DOUBLE-ACTING DIESEL ENGINE.

ENGINEERING.

FRIDAY, JUNE 29, 1923.

THE PREHEATING OF AIR FOR BOILER FURNACES.

IT is at last becoming recognised that in the boiler-house rather than the engine-room by far the greatest scope for increased economy in power production is generally to be found. In the endeavour to promote greater efficiency in the generation of steam, a considerable amount of attention is now being paid to the more effective recovery of the waste heat in the flue gases. As higher and higher pressures come into use, the design of economisers becomes more difficult. The failure of the steel economiser to give anything like general satisfaction on account of its liability to corrosion, both internal and external, has checked evolution along these lines, and in the opinion of many engineers the choice lies between the cast-iron type, or nothing, so far as economisers are concerned. The cast-iron economiser has done wonderful service for very many years, but it is nearing its limitations. It is already a triumph of the founder's art, but cast-iron is still cast-iron nevertheless, with the defects of the material as well as its merits. With an equally efficient means of utilising the waste heat of the flue gases, which the boiler in the nature of things cannot absorb, the field of the economiser would be very much narrowed for its functions as a feed-water heater could largely be fulfilled by other means. Even in plants in which the boiler pressures are not high enough for the safety of the economiser to be called in question, there is generally room for a further and fuller utilisation of the waste heat than an economiser of commercial proportions can accomplish. If the setting is airtight and excess air is kept down to its proper limits, the flue gases leaving an ordinary economiser may well be at a temperature of 400 deg. F. or more, and this heat amounting to 10 per cent. of the heat in the coal is utterly wasted, as of course no modern power plant relies on natural draught. Indeed, apart from efficiency altogether, the cooler the waste gases the better for the draught plant, as less temperatures and lower volumes have to be dealt with.

The necessary conditions of success in the use of pre-heated air are not only that an efficient air heater should be adopted, but that regard should be paid to the altered circumstances under which the furnace will be working. The transference of heat from the flue gases to the incoming air through thin metal sheets or tubes is hindered by the inevitable deposit of soot or tarry matter on the surfaces, and unless there is some effective method of keeping the heater clean it soon becomes more of a nuisance than a benefit. This difficulty, however, has been entirely avoided in one of the latest types of air heaters, by arranging that there shall be no heat transference through the metal at all, so that the question of dirty surfaces becomes of minor importance. Presuming then that a suitable method of heating the air going to the furnace has been provided there is the effect upon the furnace itself to be considered. When first confronted with the suggestion to use air, heated perhaps to 500 deg. or 600 deg. F. in his furnaces, the average engineer will express grave doubts as to the durability of both his grates and his arches under such conditions. Even now grates become burnt and arches melted, and one is justified in wondering how they would behave if furnace temperatures were higher still.

Anticipation of trouble in these respects is natural, but it involves several assumptions which are worth examining. In the first place it must not be taken for granted that in a properly designed combustion space, the temperature need be very much higher than it is at present. At existing furnace temperatures about half the energy of the burning fuel is evolved as radiant heat and the proportion rises with great rapidity as the temperature increases. If this radiant heat has direct access to the tubes of the boiler instead of being reverberated back on to the fuel by a white-hot arch, not only will steam raising be more rapid but the furnace temperature will soon reach a condition of equilibrium not greatly in excess of its previous state. That this is what occurs in practice is proved by certain tests carried out by the Swedish Steam Boiler Association on a water-tube boiler which could be operated either in conjunction with an economiser or alternatively with a Ljungström air heater. In the first case, with a temperature of the combustion air of 104 deg. F., 29·2 lb. of coal were burnt per square foot of grate per hour, the furnace temperature being 2,250 deg. F. and the CO_2 amounting to 9·3 per cent. When using the preheater, the combustion air entered the furnace at a temperature of 545 deg. F., and when burning 29·9 lb. of coal per square foot the temperature was only raised to 2,460 deg. F. with a CO_2 content of 10·4 per cent. The feed water temperature at entrance to boiler was 172 deg. F. with the economiser in operation and 138 deg. when heated by other means, but in spite of this, the higher furnace temperature increased the evaporation from 5·9 lb. to 7·2 lb. per square foot of heating surface per hour. The efficiency of the boiler and economiser combination was 69·6 per cent., while that of the boiler and air heater was 83·2 per cent.

The ordinary furnace arch, as used with a chain-grate stoker, is not only a source of continual expense and trouble to maintain, but it does harm by shielding the boiler tubes from the radiant heat which they would otherwise receive. The universal failure of attempts to promote boiler efficiency by burning the fuel in some kind of external furnace under ideal conditions and using the hot gases only to heat the boiler, shows the importance of the part played by direct radiation of heat from the fire, and suggests that all obstructions in the path of this radiation should be removed if possible. Unfortunately, with most classes of coal an arch is necessary for heating and igniting the fuel on a chain-grate stoker. If, however, as appears very probable, the use of highly preheated air so facilitates combustion as to enable the arch to be very much shortened, or possibly done away with altogether, the adoption of preheating will bring about a reduction of just those troubles which it might be feared would be accentuated. With the abolition of the

arch one of the greatest drawbacks to the chain-grate stoker would vanish. Whether this will be practicable time alone will tell, but we understand that in at least one instance it has been found possible, when using preheated air, to remove the front and most troublesome part of the arch, retaining no more than the construction of the setting made necessary.

If we may assume that the arch difficulty is not going to be a serious one, there still remains the question of the durability of the grates. This, again, can only be determined by experience, but with commonsense design there appears no reason to suppose that a grate cannot be adequately cooled with air at a temperature of say, 600 deg. F., as this is still more than 2,100 deg. F. below the melting-point of cast-iron. The real reason for the burning of ordinary grates or fire-bars is the excessive heating surface in contact with the fuel as compared with the area from which heat can be carried away by the incoming air. The thinner and deeper the bar, or the chain link can be made, the greater the ratio of cooling to heating surface and the less the danger of burning. Iron, moreover, is now available coated with a superficial alloy of aluminium, which renders it highly resistant to furnace conditions, but even with ordinary metal and good modern grates no particular trouble seems to be experienced when heated air is used.

That the anticipated difficulties in connection with arches and grates when preheated air is used are not considered very seriously by engineers in a position to judge may be gathered from the fact that Sir James Kemnal hardly alluded to them in his paper read last Tuesday at the summer meeting of the Institution of Mechanical Engineers at Glasgow. In this paper, which we reprint elsewhere in this issue, he raises, however, several points which are likely to be hotly contested by the advocates of air-heating. His computation that the boiler surface must be increased by 15 per cent. or 20 per cent. if an air heater is fitted instead of an economiser, the overall efficiency being the same, is hardly borne out by tests such as that which we have quoted above. The assumption that about half of this increase in surface is necessary to absorb the recuperated heat is also hardly acceptable, for the increase in the proportion of radiant heat, due to the hotter fire, should easily enable the same boiler to do 8 per cent. more work without increase of surface, and with substantially the same outlet temperature.

The whole question of air heaters *versus* economisers, is, as Sir James Kemnal says, in a controversial state, but data are being rapidly accumulated. Recent advances in air-heater design have enabled makers to guarantee to reduce the temperature of the flue gases directly from 570 deg. to 212 deg. F., and to supply air to the furnaces at a temperature of 390 deg. F. The apparatus necessary to do this is much less in size and only about one-sixth the weight of an economiser, which, moreover, for practical reasons could not be designed to absorb so large a proportion of the waste heat of the flue gases. Heaters of this type can be most conveniently placed immediately above the boilers in a power station in the natural path of the outgoing gases, as apart from their efficiency, their lightness and small size render unnecessary the heavy structural work required to carry large economisers. The fuel saving which air preheating has brought about in many instances is quite remarkable. In our issue of July 7 last year we published official tests showing an increase of boiler efficiency from 66·9 per cent. to 77·6 per cent. by this means in one instance, and an increase from 59·3 per cent. to 74·3 per cent. in another. Under more favourable conditions boiler efficiencies up to 90 per cent. have been recorded, and the extent to which air heating is being adopted in large plants both in this country and abroad bears witness to the economies which engineers expect to realise from the practice.

THE PRODUCTION OF AIR-DRIED PEAT.

IF vast fields of vegetation had not fossilised into coal, peat would have a higher reputation and be esteemed a more promising fuel. While, however, coal deposits are still unexhausted, and men can enjoy the probably transient supplies of mineral oil, the investigation of peat as a fuel seems to demand an unusually sanguine, provident, or conscientious mind. The considerable time and money that have been spent on the subject in countries with great peat deposits shows that such minds exist; and the latest evidence of their seriousness is the Fuel Research Board's dedication of the entire first section of its annual report to the subject of the production of air-dried peat, as set out in comprehensive reports by Professor Pierce Purcell and Mr. E. J. Duffy.*

As Sir George Beilby remarks, in presenting the report, though the winning of peat on a small scale has been practised successfully from time immemorial the problem of large-scale production is far more difficult. First and last, the trouble arises from the fact that though for fuel and, indeed, for other purposes, peat has to be used as a solid, nine-tenths of it or more is an incombustible liquid. Soap-makers in some export markets are said to have had a saying that a fortune awaited the man who found out how to make water stand upright, and Nature seems to have had some such purpose in view when she developed peat. Even drained bogs of peat may consist of a mass of water containing 10 per cent. of solid matter, or even less. They are found, as Mr. Duffy points out in his report on Irish experiments, not only in low-lying plains but on the sides of mountains, where the cells, pores or interstices of the peat hold the water so tenaciously that it is not separated and discharged on to a lower level by the constant operation of the force of gravitation. If a large block of peat is cut out of the bog, moisture does not flow from the sides, and even the vertical face of an old exposed turf bank, of which more than seven-eighths is water, does not as a rule sweat water except after rain.

To use such material for fuel means therefore handling a far greater weight than that of other combustibles. For practical purposes it must first be dried to at most 25 per cent. to 33⅓ per cent. moisture; and though to anyone unaccustomed to dealing with figures of the sort it does not look so intuitively, to reduce 90 per cent. moisture to 33⅓ per cent. means removing nineteen-twentieths of the original water, and every ton of peat dried to 25 per cent. moisture takes 7½ tons of raw peat with 90 per cent. to produce it. The product, again, has a relatively low calorific value; for Irish peat reduced to this dryness Professor Purcell puts the net figure at 6,900 B.Th.U. per pound, against, say, 11,500 B.Th.U. for industrial coal. To obtain, therefore, the heat of a ton of coal takes about 1⅔ tons of peat dried to 25 per cent. moisture, derived from 12½ tons of raw peat; and as even machine-formed dried peat, which is nearly twice as dense as hand-formed, occupies at least twice the volume of the same weight of coal, the dried peat required to furnish the heat of a ton of coal will measure 3⅓ times as much as the coal. Considerations of this sort do not count for much in determining the domestic use of peat in districts near a bog and far away from supplies of coal; but they have an obvious and important bearing on the question of whether peat can be used economically on a large scale, when it comes into competition with coal and oil.

A further consequence of these facts is that a large-scale production involves relatively enormous workings, the area of which is the greater because up to the present the only method of getting rid of moisture that has been uniformly successful is air-drying, which requires large spreading grounds. For anything approaching economical production peat must be got mechanically, and up to now, according to Professor Purcell, mechanical excavation has not gone deeper than 16 ft., while the depth of the large bogs in the centre of Ireland varies from 20 ft. to 40 ft. Assuming, however, that machines could be designed to work successfully and economically on bogs of greater depth than hitherto have been worked mechanically, a bog 20 ft. deep when worked out would only have yielded some 3,200 tons of 25 per cent. air-dried peat for every acre of area, and to provide for an output of 100,000 tons for a period of years Professor Purcell estimates would require a bog of some 8 sq. miles.

The preliminary objection to such workings that suggests itself naturally—that the soil would not support machinery of the necessary weight—seems to have been overcome. In his classical paper on traction on bad roads or land, Mr. Legros puts the pressure exerted by a man standing on the sole of one boot as from 6 lb. to 7 lb. per square inch, and quotes chain-track tractors for soft and swampy country which have been built with an insistent load as low as 1·8 lb. per square inch. Professor Purcell observed, in Canada, a plant weighing 30 tons working without difficulty on a Canadian bog with an insistent load of 2·5 lb. per square inch, which is comfortably within Mr. Legros's figure. The time, however, during which peat can be won—and winning has to include enough drying to allow the peat to be handled and got away—is limited by the weather, and in some countries by the temperature. In Ireland it is reckoned at 125 to 130 working days per year, in Germany it varies from 92 days to 179 days, in Sweden 96 days to 121 days, and in Canada it is estimated at not more than 95 days. The slices of peat that are cut and spread out for drying have to be thin, so as to enable the peat to be dried and removed and the spreading ground to be available for a second batch during the same season, so that the working faces to be covered in a season must be of considerable length. In Professor Purcell's estimate, for instance, where the season is assumed nominally to extend to 158 working days, and actually about a fourth less, the length of working face required for the assumed production of 100,000 tons a year—equivalent thermally to, say, 60,000 tons of coal—with six plants each of 10 tons per hour output, is just on 11 miles, with about the same length of spreading grounds over a quarter of a mile wide.

Circumstances such as these, inseparable from the large-scale working of peat, by no means show conclusively that it is economically impracticable, but they do show that schemes for such workings demand close investigation before they are approved. The material, moreover, presents intrinsic difficulties in the variability of its composition, which are the more serious because it may be questioned whether even now the behaviour of peat under all circumstances is fully understood. In the Irish experiments, for example, it was found that the process of maceration, by which the various constituents of peat are broken away from each other and their fibres remixed so as to lie more or less uniformly in all directions, did not affect the density of the peat treated; whereas in Hausding's handbook on getting and using peat (which is so far the standard authority on the subject that the Fuel Research Board went to the considerable expense of having it translated into English and published) it is stated repeatedly that maceration increases the density by 25 per cent. to 60 per cent. The examination of actual developments in other countries is not much more encouraging. The most extensive use of peat up to now seems to have been in Russia, and arose from the high price and shortage of coal during the war, the Russian consumption of peat in 1918 having been about 10,000,000 metric tons, or nearly double its pre-war figure. The largest installation described is one begun at Wiesmoor (Prussia) in 1908; it is now operating about 7 sq. miles of bog, to be extended later to about 24 sq. miles, and is producing about 60,000 tons of air-dried peat a year. The whole of this production, however, is absorbed in supplying part of the consumption of a large power station, generating and transforming power up to 60,000 volts for long-distance transmission, and the economical circumstances are therefore exceptional. In Sweden peat, especially in the form of desiccated powder, has been used for some time past on some lines for firing locomotives, but only one factory remains at work out of three that have been started.

Having regard to the large deposits of peat in Ireland and in parts of Great Britain, the inquiries described in the present report, which include the results of investigations made on the spot in Canada, Germany and Sweden into what is being done in those countries, and of two years' practical working on two Irish bogs, may have been expedient; but they do not seem to show that the technical prospects

* Report of the Fuel Research Board for the years 1922, 1923. First Section: "The Production of Air-Dried Peat." Published by H.M. Stationary Office. Price 5*s.* or 5*s.* 4*d.* (post free).

and relative economic importance of the production of peat on a large scale are such as to create any anxiety to see the Board's energies spent on further work on the same subject while so much remains undetermined in regard to the use of fuels with better established credentials. The cautious terms of the report itself and of Sir George Beilby's introduction do not suggest any illusions as to present practical prospects; but it may be questioned whether it was necessary to subject the report to the indignity of issuing it without an index. Apart from the Irish experiments, its chief value lies in collecting under one cover what hitherto has had to be sought up and down the world; and a compilation of this sort loses a large part of that value if it is not analysed in detail in a sufficient index. The analysis of the text, moreover, which is involved in preparing an adequate index sometimes discloses variations of treatment and even inconsistencies that weaken the authority and the usefulness of a report, and add greatly to the difficulty of reading it. That modern technical books leave much to be desired in this respect is an excuse that would hardly lie in the mouth of quasi-exemplary bodies such as the Fuel Research Board or the Research Department.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE summer meeting of the Institution of Mechanical Engineers opened in Glasgow on Tuesday morning last, when members assembled in the Examination Hall of the Royal Technical College and were welcomed to the City of Glasgow by the Lord Provost, Sir Thomas Paxton. In extending the welcome of the city to the Institution, Sir Thomas recalled the fact that the Institution had visited the city in 1856, '64, '79, '95 and 1901, and that the meeting of '56 had been the first summer meeting to be organised by the Institution. Glasgow was essentially an industrial city associated closely with engineering, and numbered among her former citizens many famous mechanical engineers. It was natural, therefore, that they should welcome the Institution of Mechanical Engineers. He hoped their stay would be educative as well as full of pleasure and enjoyment.

Professor Mellanby followed on behalf of the local reception committee, with an excellent short speech of welcome, at the close of which Sir John Dewrance, president, replied on behalf of the Institution. Members then adjourned to the Societies' Room for the reading and discussion of papers, only two of which were taken that morning.

SUGAR MACHINERY.

After formal business, the first paper to be taken was one entitled "Sugar Machinery," by the Right Hon. Lord Invernairn. This we reprint elsewhere in this issue. In the unavoidable absence of the author the paper was presented in somewhat curtailed form by Mr. A. E. L. Chorlton. After passing a vote of thanks to Lord Invernairn for his paper the president remarked that it dealt only with cane sugar, and not with beet sugar manufacture. Possibly Glasgow was more interested in the former. Mr. Chorlton said he had no doubt if it were thought it would be advantageous, that a section dealing with beet sugar could be added to the paper. Certainly Glasgow manufacturers could make machinery for the latter system as well as for the former.

WATER TUBE BOILERS AND CRANES.

The second paper to be taken was by Sir James H. R. Kemnal, and was on the subject of "Water-Tube Boiler and Crane Construction." This paper we also reproduce elsewhere in this issue of ENGINEERING *in extenso*, and we therefore proceed here to the discussion which was opened by Mr. H. E. Yarrow.

Mr. Yarrow said he did not agree with the author's statements with regard to the circulation of horizontal and vertical tube boilers, to the effect that this was not so good in the latter as in the former. Naval experience proved conclusively that where a high rate of evaporation per unit of heating surface was required the vertical disposition was far the best. The vertical arrangement also had the advantage that with one upper drum and two sets of tubes a larger heating surface was obtained in a way to be of the most value and service. The arrangement also ensured ample combustion space. He thought generally the design preferable to facing the fire with brickwork. With regard to detrimental strains said by the author to be set up in the lower drums, he only knew of two or three cases of grooving in such drums in boilers which had been hard worked in war service. In these cases the lower drums had been D-shaped and naturally under pressure tended to become circular. It was now the practice to make them circular and the trouble was eliminated.

Mr. W. H. Patchell said they had come to the Mecca of the water-tube boiler and were fortunate in finding the prophet at home, but like most prophets, the author had not told them all they wanted to know. He was sorry the author had not stated that the Holborn Viaduct generating station was not only the first such station to use the water-tube boiler in this country, but was the first in the world to do so, the station having been actually got running before the Edison Company finished another plant in the United States, also fitted with water-tube boilers. He noticed that boiler plant put in forty years ago was still working. Would the author give a forty years' guarantee for the boilers he was now turning out? The author and Mr. Yarrow had spoken of the effect of the arrangement of the tubes in connection with circulation. He thought that the arrangements at the ends of the tubes are no less important. Good combustion space was also essential, and makers of the horizontal tube type were endeavouring to obtain this by raising the tubes. Water screened walls were also being adopted. Air heaters had co-lateral merits, but they brought troubles in their train to the stokers and brickwork. The economiser was useful as by the storage of hot water it provided a flywheel effect of value. He was sorry the author did not go into the question of high pressures. He knew of installations at 800 lb. or even 1,000 lb. per square inch pressure, and they would have to get ready for that sort of thing. The author mentioned 88 per cent. efficiency as being realised. He would be glad if he would give full particulars of this case.

Mr. D. Adamson who followed, said he thought the historical part of the paper the most interesting, but he would like to add that before the date of 1882 mentioned by the author, his firm had built, in 1878, a water-tube boiler to work at 120 lb. pressure with tube plates of steel, the rest of the boiler being iron. No cast-iron was used in the boiler at all. The tubes were inclined at 15 deg. He would like to know why 15 deg. was the angle usually adopted. In about 1884–5 the Manchester Steam Users' Association had gone into the question of the use of cast-iron in boilers and had condemned it. Troubles certainly arose with water-tube boilers of the vertical type due to the varying water line, and to cracks in the lower drums, due to cold water lying in them. There were, however, troubles also with the horizontal type which the Americans had tried to get over by improving circulation by means of separate drums for the lower tubes. He thought water-tube boiler makers would do better by adopting longitudinal paths for the gases instead of cross-baffling. The value of high velocities was not yet sufficiently appreciated. Water-tube boiler makers argued too much on total heating surface without considering its effectiveness. If compared on a proper basis there was no doubt that an externally fired flame tube boiler gave better steam production.

Mr. F. Clements also would have liked more information. He referred to the installation of Babcock boilers at the Parkgate Works at Rotherham, fitted for burning blast-furnace gas with a supplementary installation for pulverised coal. With this addition they were able to increase their steam production about 60 per cent.—a boiler designed for 30,000 lb. of steam per hour could be pushed to 50,000 lb. He thought the horizontal tube boiler an excellent case of excellent mechanical construction overcoming natural laws. The lower tubes were in contact with flame at a temperature of 1,500 deg. C.—that became reduced to 600 deg. C. at the upper tubes. What proportion of the production did the author think came from the lower tubes? He thought their condition approached that of a flash boiler. In fact, in these tubes the scale was hard and vitrified while in the upper it could be brushed out. Had intensified circulation been tried in the lower tubes? It was not at all easy to treat all waters so as to overcome corrosion troubles—especially feed-water drawn from rivers which had come through industrial towns.

Mr. T. Clarkson said it was cheaper to make high-pressure steam superheated than low-pressure steam superheated to the same temperature. There was little material advantage in going above 700 deg. F. They had gone to 1,000 deg. With a reciprocating engine about 650 deg. F. was the limit for superheating, but with turbines you could go higher if the materials would stand it.

Mr. P. Rushforth said an economiser was an essential adjunct to all boilers allowing gases to escape at 600 deg. to 650 deg. F. The economiser was a fuel economiser and not a water economiser, as stated by the author. He thought that water-tube boiler makers tried to crowd too much into one casing, including boiler, economiser, air heater, fan and sometimes chimney. Economisers as usually fitted amounted to a few tubes which were really an extension of the heating surface. An economiser should really be treated as a thing apart to deal with the gases leaving the boiler. If the gases left at 650 deg. F., about 15 per cent. economy could be secured with an economiser. Could the author give further particulars regarding methods of preventing corrosion in steel tubes?

In reply to the discussion Sir James Kemnal said he knew how much he had not said in the paper. What he had said regarding the horizontal and vertical tube types was the result of his experience, which covered the manufacture of both types. The vertical tube type had given excellent results in torpedo-boat work where a great quantity of steam was required. Mr. Patchell seemed to want him to act as an insurance company. He was quite prepared to do so for a consideration, just as the insurance people did. Combustion space was given more attention now, owing to the tendency to work boilers at higher rates. Higher steam pressures were certainly being adopted, but there was a good deal of inventing to be done in that direction yet. The 15 deg. inclination for the tubes was a compromise between circulation and manufacturing. The range was between 10 deg. and 20 deg. The lower tubes probably did more work. In fact, it had been shown to be possible with only one row to get an output of 100 lb. per square foot of heating surface, but it was not possible to make a boiler of one row as the purchaser would think he was not getting value for his money. Intensified circulation had been tried, but the results did not appear to justify the arrangement. The difficulty with high superheat was that the superheater elements would not stand. Most engineers preferred all their heaters, &c., in one casing and not spread out. The cast-iron economiser was fundamentally unsuited to modern pressures.

A vote of thanks proposed by Sir J. Dewrance to Sir J. Kemnal, terminated the meeting. In the afternoon members visited a number of works, particulars of some of which have been given in our columns recently. In the evening a very enjoyable conversazione was held in the Glasgow City Chambers, at the invitation of the Lord Provost and Corporation of the City. The guests were received by Sir T. Paxton, Lord Provost. The meeting was continued on Wednesday morning with the reading and discussion of further papers, the discussion on which we shall report in our next week's issue. Visits to various works occupied the afternoon and the Institution dinner took place on Wednesday evening. Yesterday was devoted to whole-day pleasure excursions, while for to-day whole-day visits are arranged, including a trip to Kilmarnock, where a round is to be made of several works.

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY.

THE annual inspection of the National Physical Laboratory by the General Board was held on Tuesday last, when a very large number of visitors were received in the Aerodynamics Building by

Sir Charles Sherrington, Pres.R.S., ex-officio chairman of the Board, Sir Arthur Schuster, F.R.S., chairman of the Executive Committee, and Sir Joseph E. Petavel, F.R.S., director of the Laboratory. The Report of the Executive Committee for the year 1922 records the death of two members of the Board, namely, Sir Alfred Kempe, who, as treasurer of the Royal Society, had become treasurer also of the National Physical Laboratory in 1900, when it was founded, and Dr. J. T. Merz, who had joined the Board in 1919. While a large amount of work continues to be carried out at Teddington for the co-ordinating research boards of the Department of Scientific and Industrial Research, the Executive Committee have resolved to appoint advisory research committees; the members of the first of these committees, elected last winter, Sir J. J. Thomson, Sir W. H. Bragg, and Sir E. Rutherford, have suggested additions to the research programme for the year 1923–24, and have also reported upon the general requirements of the Laboratory and upon additional buildings.

As we mentioned last year, the Department of Scientific and Industrial Research provides for conducting investigations on behalf of civilian Government Departments as "free service"; these investigations comprise work on the lighting and illumination of public buildings, on the ventilation of the House of Commons, on ships' lights, on "Otter" trawl boards for supporting trawling nets, and on a sea-water hydrometer. Work for the Admiralty, War Office, the Air Ministry and Roads Departments of the Ministry of Transport is done on a "repayment basis"; some of these researches, which are conducted mainly in the Engineering and Aerodynamics Departments, will also be noticed in our summary.

The widening activities of the various research associations place further responsibilities on the Laboratory staff; but it is, of course, very desirable that the members of the staff should keep in actual touch with industrial requirements. We mention in this connection that Dr. Stanton is now a member of the Forest Products Research Board, and that Dr. Ezer Griffiths is president of an International Committee on heat-insulating materials. The Laboratory has lost the services of Mr. W. Hugo, of the Thermometry Division, one of the original members of the staff, formerly at Greenwich Observatory, and Kew; of Mr. A. Blackie, now senior assistant in the Fuel Research Station, Greenwich, and of Dr. J. L. Haughton, now in the Woolwich Research Department. The most notable other change is that Dr. G. W. C. Kaye has been appointed Superintendent of the Physics Department; this is a new creation, the director having so far acted also as superintendent of this department, and the new superintendent is anxiously waiting for his physics building, the need of which has long been recognised. Victoria House, a small building taken over, is being equipped for the new Sound Division and other physical work; but a general physics building is required.

The total numbers of tests carried out in 1922 differ little from those of the preceding year and are below those of the year 1919–20; but those totals do not characterise the work done. The report does not discuss finances this year, and it has no particular donations to record. Mr. G. R. Edwards, B.A., assistant to the secretary, Mr. F. J. Selby, M.A., has added a very welcome and complete subject-matter index to the report, which this year runs into 227 pages.

We begin our comments of the work done in the year 1922, supplemented by notes upon further progress, with the Engineering Department, of which Dr. T. E. Stanton, F.R.S., is superintendent. We shall refer to our summaries of previous years; our report on last year's work was commenced on page 820 of our issue of June 30,* 1922, and was continued on July 7, and in subsequent issues.

Engineering. Cylindrical Journal Lubrication at High Eccentricity. Boundary Lubrication. Aquadag. (Messrs. Stanton, C. Jakeman, J. H. Hyde).—The work for the Lubrication Research Committee, the further results of which are being communicated to the Royal Society, is being continued at high loads. In Beauchamp Tower's bath lubrication experiments of 1883, the load at seizing even with fixed oils was 600 lb. per sq. inch of the projected bearing area; but his arc of contact of the oil film was about 170 deg. By increasing the radius difference between bearing and journal steady conditions of lubrication and a hydrodynamical state of flow have been maintained with an arc of contact reduced to 14 deg., at a maximum fluid pressure of 3½ tons per square inch, without bath or forced-feed lubrication; a pure Reynolds film remained at a radius difference of 0·06 in., corresponding to 6 per cent. on a 1 in. journal. With large radial differences the expansion effects of elasticity and temperature of the bearing metal became negligible, and the temperature of the oil film can be measured. Complete sets of observations have been made with sperm oil, rape, castor and a mineral oil; the ordinary equations for flow were found to hold when the inclined surfaces were at distances apart down to 1·2 μ (1 μ = 0·001 mm.).

Since a film cannot be maintained in a bearing when the relative velocity is zero (Sommerfeld), Dr. Stanton is also experimenting with rocking shafts by suspending a pendulum of a weight of 250 lb. from a bracket in such a way that the damping period of the pendulum can be determined. The steel journal is grooved in one direction, the phosphor-bronze bearing in the other, and the actual bearing surface of only ¼ sq. in. is loaded at the rate of 1,000 lb. per square inch. Plotting the angle of swing against the time in seconds, Dr. Stanton obtains rectilinear curves when applying different lubricants to the bearing. With pure castor oil the rate of damping per oscillation was 0·133 deg., with Bayonne oil 0·185 deg.; on adding 1 per cent. of oleic acid to the Bayonne oil the rate was 0·151 deg., and similar influences of the addition of oleic acid were observed with other lubricants. With an increased pendulum weight of 500 lb. and a pressure rate of 2,000 lb. per sq. in. the following damping coefficients D and friction coefficients μ were obtained; castor oil D = 0·132 deg. μ = 0·092, Bayonne oil D = 0·184, μ = 0·128, same with 1 per cent. of oleic acid, D = 0·153 deg., μ = 0·105; Shell Mex. super light, D = 0·156 deg.; μ = 0·108; same, super heavy, D = 0·145 deg. μ = 0·100.

When noticing Mr. Jakeman's tests of heavy oils at temperatures up to 250 deg. C. and pressures of 1,000 lb. per square inch in bearings at 1,300 r.p.m. we mentioned last year (page 7, July 7, 1922) that plotting the friction μ against temperature, he obtained a U-curve, showing a minimum friction near about 100 (90 to 120) deg. C. After that the friction increased, again with rising temperature until seizure would occur. Some instability in the oil was suspected to occur at those minimum friction temperatures. But there is no indication of that; as the temperature rises, the length of the oil film contracts and the friction then increases; minute variations in the surface of the shaft or the bush have a very great effect on the observed pressure on the film. The four best oils found, "axiom," superheated steam cylinder oil, "mobil B" and "castrol" have particularly been tested to determine both the maximum load at which a running temperature of 200 deg. C. can be reached, and the seizing temperature at higher loads up to 2,500 lb. per square inch. Axiom oil seems to answer as well as any, but it is liable to contain water, and that seriously reduces its safe running temperature. Mr. Jakeman is also investigating the question whether axial thrust on roller bearings is really so much to be avoided as is often asserted. He puts the double normal radial load on a bearing and then reduces the radial load more and more, finally having only an equivalent axial thrust on the bearing. This the bearing is found to stand quite well, which is not surprising in so far as in motor car bearings axial thrust is not especially allowed for.

Aquadag has been tested for the Lubrication Committee in order to determine its suitability as a lubricant for sliding surfaces in the presence of superheated steam, *e.g.*, for the piston rings of steam engines; it has not been found to answer. The apparatus used consists of a steel cylinder upon which two interrupted square threads are cut and which revolves upon a hollow shaft supplying superheated steam. Over the threaded mandril a cast-iron cylinder (representing the engine cylinder) is so placed as to give a pressure of 5 lb. per square inch. The inner cylinder surface is lubricated with aquadag, and the particular object was to ascertain whether the coating of aquadag could be maintained in contact with superheated steam. The torque of the cylinder was measured and was found to increase rapidly, because the aquadag cakes and is driven out by the steam.

Force and Couple Coefficients of Projectiles (Dr. Stanton). The first stage of a research conducted for the Ballistic Air Resistance Committee covering the calibration of a Pitot tube for high-speed air currents was noticed in our issue of June 30, 1922, page 820, when the applicability of Rayleigh's formula for the ratio p_2/p_0 (Pitot pressure to static pressure) was confirmed for the intermittent flow of air from a large drum (16 ft. long, 4 ft. diameter), supplied by a 50 h.p. Brotherhood compressor. The same apparatus is now fitted with further appliances for measuring the drag, wind force and couple coefficient of a small model projectile. The air leaves the drum at a pressure of up to 65 lb. per square inch through a flexible bifurcated 3-in. pipe and enters the wind channel proper, only 0·8-in. in diameter, through a vertical gunmetal nozzle, which is, *e.g.*, 0·5 in. wide at the top and widens out to 0·8 in. again, the total angle of divergence being 4½ deg. When working at different speeds a special nozzle has to be used for each speed, lest turbulence be set up. The 1/33 scale model projectile has a diameter of 0·1 in. only. The experiments have been made over a range u/a from 0·3 to 2·3, where u is the velocity of the air and a the velocity of sound. On the whole the results agree well with those obtained from firing trials by ordinary shells, the coefficient rising rapidly with increasing u/a ratio. But the small wind channel curves fluctuate, *i.e.*, drop and rise again, as the ratio passes from 1·3 to 2·3, at which the full size firing trials show no fluctuation, and this has been ascribed to a disturbance in the normal pressure distribution on the base of the shell caused by the interference of the waves reflected from the walls of the narrow channel. On Professor C. V. Boys' suggestion this feature is being investigated by the photographic method which permits of studying the nose and tail waves and reflected waves.

The photographic study of the motion of projectiles in the underground shooting gallery, conducted by Mr. R. G. C. Batson and Mr. H. J. Tapsell for the Ordnance Committee, likewise previously mentioned, is still troubled by the "slack" in the standard naval Hotchkiss gun mounting of the 1-in. aiming rifle (muzzle velocity 1,100 ft. per sec.) and 1-in. 3-pounder Hotchkiss Q.F. gun (muzzle velocity 3,000 ft.) so far tried. The deviations from the line of sight in successive shots are much larger than a variation in the quality of the ammunition would account for. The effect of the muzzle blast is also very disturbing. The first discharge of the gun wrecked the door and door framing of the tunnel, and pressures up to 500 lb. per square inch were measured at the end of the tunnel. By the aid of wire netting and heavy curtains those effects have been diminished, and some photographs have been obtained with two and three of the eight "jump" cards which are mounted in series, 15 ft. apart.

Hardness Tests (Messrs. Batson and G. A. Hankins).—The results of the research on scratch hardness and indentation hardness were communicated to the Institution of Mechanical Engineers in April last.* The points are that, to obtain scratch values comparable to Brinell numbers the diamond must produce furrows by distortion of the surface of the material and not act as a cutting tool, and that there is no definite relation between the results of ball tests and of cone tests.

Efficiency of Spur, Bevel and Chain Gears (Mr. J. H. Hyde). The worm gear testing machine of the Lanchester type was described in our issue of July 1, 1921, and the adaptation of the helical gear machine presented by the Power Plant Company, of West Drayton, to gear-testing was mentioned last year in our issue of July 7. Inverted tooth driving chains of 1½ in. pitch fitted to the former machine will give efficiencies from 96·5 to 98 per cent., the efficiency decreasing as the speed increases and also when the chain is not flooded

* See ENGINEERING, April 27, page 537.

with lubricant; yet in many cases a heavy dash pot on the frame is not required. Roller chains gave under the same conditions efficiencies of 96 to 97·5 per cent., though not the 99 per cent. sometimes claimed. The second machine shows that helical spur gears of cast iron, such as are used on high-speed turbines, will give 99 per cent. efficiency, provided a splash feed of oil be kept up. The machine used for the experiments is so delicate that any change in the splash feed can at once be seen. Fluctuations of efficiency are further caused by very slight changes of a few hundredths of an inch in the gear centres.

Reinforced Concrete.—With regard to Mr. Hyde's testing of reinforced concrete, we will only mention that large floor specimens are now built up of steel joist frames, 15 ft. by 6 ft., 6 in., concreted in a thickness of 9 in. maximum, which are loaded not only at the centre, as originally done, but on two points so that the central third of the floor is under uniform load conditions. An illustrated description of the large testing machine constructed by Messrs. Redpath, Brown and Co., appeared on page 484 of our issue of October 20 last year.

(*To be continued.*)

THE FUEL RESEARCH BOARD.

(*Concluded from page* 761.)

TESTS ON INDIVIDUAL COALS.

RESULTS have been published of tests on three types of coal carried out in the plant and by the methods already described. These tests have led to important practical conclusions, which seem likely to become more general and quantitatively more definite as the methods are applied to more types of coal. In the meantime some of the principal results may now be stated; and thanks to the full and unrounded detail in which the results already obtained have been set out, it is possible to form an idea of the extent of experimental control that has been obtained over the industrial processes, and of some directions in which further investigation may be required.

Coals and Sampling.—The coals used came respectively from Durham, South Yorkshire and Lanarkshire, and were of well-contrasted types. The tests on the Durham coal were made on a single cargo; the Yorkshire and Scottish collieries are said to have supplied a very uniform quality for the entire period of the tests, and the Scottish supply is said to have been exactly similar to that used in the Uddingston tests, with which the station tests were to be compared. Having regard to the elaborate means of sampling adopted in the station tests, it is unfortunate that no data seem to have been published to show how accurately the samples obtained with such care did in fact represent the bulk. In the circumstances of the station tests this indeed is of no great consequence. The results of the tests were obtained not from the samples but from the entire bulk; and the run of these results, as indicated by the variations of the yields of the several products with the percentages of steam, was regular enough to permit conclusions to be drawn safely on the strength of the information available as to the general uniformity of the coal supplied without reference to its exact analysis.

At the same time all coal users have to regret the fact that up to now a method of sampling which is both trustworthy and conveniently practicable under works conditions has yet to be agreed. On the face of the station analysis it is quite possible that the methods of coal sampling used in these tests may have represented the bulk accurately. The samples taken for the three tests made on the single cargo of Durham coal agree in calorific value within 1 per cent. of the mean, and the two Scottish samples within little more; probably as close as the supplies themselves can be expected to have been. The five Yorkshire samples, on the other hand, varied up to just on 5 per cent. from the mean; and while it does not seem impossible that the calorific value of the bulk itself may have varied to the same extent, some further information would be desirable before assuming that it did. Not for the interpretation of these particular tests but for the more general criticism of the method of sampling it would be useful for the point to be cleared up, as it may be hoped will be done by investigations now in progress.

Decomposition of the Steam.—More gas per ton of coal was obtained in all tests with steam than from those on the same coal without it. The analysis of the additional gas produced by steaming, calculated as the difference between the volumes obtained with and without steam, shows that the process had produced a substantially different effect from that of purely water-gas reactions. In the Yorkshire coal, for instance, much higher percentages of carbon were burnt completely to carbonic acid and formed into methane and other hydrocarbons than are found in water gas, while the percentage of carbonic oxide was correspondingly less. These reactions must have affected the thermal position within the retorts, and may have had something to do with such irregularity as was found in the temperatures of the combustion chambers, though this may have arisen still more through sticking of the charge and consequent rise of temperature within the retorts. The calorific value of the additional gas was increasingly lower as the percentage of steam, calculated on the weight of coal carbonised, increased, though the increase was by no means regular, and the calorific value was even slightly larger with 5 per cent. steaming than with none.

A determination for the tests with steam on the Yorkshire coal of the excess of hydrogen in the gas, tar and sulphate of ammonia over what was found in the test without steam, showed that in the 5 per cent. test the whole of the hydrogen in the steam was exactly recovered, so that the steam had been completely decomposed, while the percentage of decomposition fell rapidly with increase of steam, till with 30 per cent. of steam only 52·3 per cent. was decomposed. To what extent modifications of design and temperature would enable a given coal to decompose steam more completely at the higher percentages of steaming seems to be among the questions that call for further investigation.

Yields of Products.—In every test the volume of gas made with increased steaming increased more than the calorific value fell off, so that with increased steaming there was always an increased yield of potential heat in the total volume of gas made per ton of coal. Without steam only about 21 per cent. of the total potential heat of any of the coals was converted into potential heat in the gas, a figure fairly up to average present practice, and apparently a good deal higher than was usual earlier in the century. Carbonised without steam, the Yorkshire and the Durham coals gave about the same volumes of gas, and as the net calorific values of the gases were respectively 476 B.Th.U. and 451 B.Th.U., the thermal value of the Yorkshire make of gas was about 5 per cent. more than that of the Durham.*

With steam, however, the volumes of gas differed widely, and their thermal values even more. Thus with about 5 per cent. steam the Durham coal gave about 2½ per cent. more gas of about 2½ per cent. higher calorific value than when carbonised dry, or a gain of something under 4 per cent. of potential heat, while the Yorkshire coal gave about 25 per cent. more gas of something under 4 per cent. lower calorific value, or a gain in potential heat of nearly 15 per cent. With about 21 per cent. of steam the Durham coal gave a make of gas not quite 30 per cent. in excess of the yield when carbonised without steam with a calorific value of 410 B.Th.U., or a gain in potential heat of just over 15 per cent.; but the Yorkshire make was more than 70 per cent. in excess of what it gave without steam, with a calorific value also of 410 B.Th.U. or a gain in potential heat of 45 per cent. Carbonised with 30 per cent. of steam, the Yorkshire coal gave nearly double the volume of gas that it gave when carbonised without steam with a calorific value of 385 B.Th.U., or a gain in potential heat of 55 per cent., and a conversion of over 35 per cent. of the potential heat in the coal into potential heat in the gas.

In every test the yield of coke was less with steam than without, and so in most tests was the calorific value. With the Durham coal the loss of coke was less than 0·3 per cent. for 5 per cent. steam, and less than 2 per cent. for 21 per cent. steam. With the Yorkshire coal it was considerably more, varying from about 4 per cent. with 5 per cent. steam to over 8 per cent. with 20 per cent. steam and just under 12 per cent. with 30 per cent. steam. The decrease in calorific value varied up to 5 per cent., but more erratically, and some of the discrepancies may have been within the limits of experimental error under the conditions in question.

Steaming with about 21 per cent. of steam increased the yield of tar from the Durham coal by about 20 per cent. and from the Yorkshire by 35 per cent., with small increases in calorific value. Of sulphate of ammonia, on the other hand, 21 per cent. steaming of the Durham gave a somewhat greater increase than with the Yorkshire coal; about 37½ per cent. against 30 per cent. Similar and still greater differences in the yield of each of these products were seen in tests with 5 per cent. of steam.

The above yields were from coal carbonised with an average temperature of about 1,260 deg. C. in the combustion chambers. Two short tests were also made at temperatures of 1,209 deg. without steam and 1,177 deg. with 22 per cent. of Scottish coal similar to what had been used at Uddingston. In these the make of gas without steam was about 10 per cent. lower than that of the other coals carbonised at the higher temperature, the calorific values of all three gases being about the same. Steaming with 22 per cent. of steam increased the make by over 55 per cent. but lowered the net calorific value from 467 B.Th.U. to 386 B.Th.U., thus showing on the whole an increase of about 30 per cent. in the aggregate available heat of the gas. The yield of coke in carbonisation without steam was about 15 per cent. lower than that of the Yorkshire coal carbonised at the higher temperature, and fell about 10 per cent. on steaming. the calorific value also falling about 5 per cent. The yield of tar, on the other hand, which on carbonisation without steam was about 50 per cent. higher than in the corresponding test on the Yorkshire coal, rose by a further 20 per cent. on steaming, and the sulphate of ammonia, which without steam gave about double the yield of the Yorkshire coal, rose on steaming by a further 30 per cent.

The absolute gain of tar per ton of coal carbonised with 20 per cent. steam were for the Yorkshire coal 34 lb. and the Scottish 40 lb.; of sulphate of ammonia 6 lb. and 11 lb. respectively.

Thermal Cost of Process.—The economical meaning of the above results, with the further chemical details of the substances included in the tar, must be worked out for each works according to the local value of the products, and so to some extent must the cost of the process, having regard to the sacrifice of some products which has to be made in order to procure an increase of others. At the same time, the labour at any works is practically constant for all the processes compared, as is the cost of the coal itself, and light may thus be thrown on the relative value of carbonisation with steam as compared with the same process without steam by considering the purely thermal costs.

Dealing first with only the heat supplied in the fuel gas and steam, and in all instances considering only the heat supplied in addition to what was used to maintaining the carbonising temperature in the setting, the first most notable result was that with 5 per cent. of steam the make of gas per ton of Durham was obtained with 1¼ therms less fuel gas and steam than was required for carbonising without steam, and the Yorkshire make with a saving of 4 therms, while the heat in the gases was respectively about 2 therms and 13½ therms greater. At higher percentages of steam the heat required for carbonisation exceeded what was used in carbonising without steam, but up to a limit varying with the coal the heat that had to be added was less than was gained in the make of gas. Thus at 12½ per cent. steam the make of gas from the Yorkshire coal gained about 24 therms per ton of coal carbonised for an additional heat supply of 3 therms in fuel gas and steam over what was used in carbonising without steam, at 20 per cent. 33 therms at an expense of 9 therms, and at 30 per cent. 40 therms

* In practice, as for instance in the statutory declared values, gross calorific values are used, presumably because they are more readily determined; but as these take credit for latent heats that are used only in the rare gas-heating processes in which steam formed by combustion is condensed, the net values seem preferable for making comparisons such as are here in question. The difference in result, however, is not great.

at an expense of 15 therms. At about 20 per cent. the corresponding figures for Durham coal gas were 11 therms gained at an expense of 8 therms, and for the Scottish coal 19 therms at an expense of 9. Economically, of course, there must be added to these gains the values of the extra yields of tar and sulphate. The thermal value of the gas produced by a ton of coal without steam was about 60 to 70 therms.

From the point of view of the heat value of the gas to be made for a given supply of fuel gas, which may be important where that supply is limited, the maximum percentages of steam that could be used in carbonising with no more fuel gas than is required in carbonising without steam, were 15 for the Durham coal, 12½ for the Yorkshire, and apparently about 10 for the Scottish. Further heat value in the make of gas requires the supply of more fuel gas. Thus if with the Yorkshire coal steamed at 12½ per cent. a further 7·7 therms can be supplied in the fuel gas a further 17½ per cent. of steam can be used with an increased heat value of 15 therms in the make of gas in addition to gains of tar and sulphate; though with this coal the gain of ammonia does not seem to continue at a higher steam percentage than 15.

The purely thermal cost of the process is, however, affected very greatly by the consumption of coke within the retorts and to some extent also by the change of the calorific value of the coke as the percentage of steam changes; though what is often the low value or even the embarrassing superfluity of coke may make it economically a factor of relatively small consequence. Account is taken of these factors by the separate measurements, as described above in respect to the heat spent on carbonisation, of the heat carried off in the flue gases and dissipated from the retort setting proper and from the preheater; and by calculating the difference between the steam and fuel gas heat and the sum of these losses to therms per ton of coal carbonised, the amount of heat required per ton of Yorkshire coal is found to be 7·53 therms with 5 per cent. steam and 9·62 therms with no steam, showing that up to some figures not exceeding 5 per cent. of steam less heat is required as the percentage of steam is increased. Above this figure it is found that the heat required increases with the percentage of steam.

To complete the estimation of the thermal economy of the process allowance must be made for the heat value of the tar. When the quantities were calculated as described above in respect to the cost of the heat gained by steaming it was found that for carbonising the Yorkshire coal with up to about 11 per cent. of steam the total extra heat after allowing for the thermal value of the tar did not exceed the heat gained in the gas in excess of its heat value when carbonised without steam. At 12½ per cent. the extra heat required did slightly exceed the extra heat produced in the gas, but at 20 per cent. fell well below it, and at 30 per cent. exceeded it rather more than before.

A comparison of the results with the thermal cost of enriched water gas shows that the retort gas obtained by steaming is produced with something like half the thermal expense of the enriched water gas, and even less in the very low percentages of steam, when the increased yield per ton is obtained with no more heat than is required for the lower yield obtained without steam, or even with less.

The actual limit of economical steaming cannot be stated in general terms; but the results obtained up to now at least demonstrate that by moderate steaming at moderate temperatures the heat value of the gas from a setting of vertical retorts can be greatly increased and the cost per therm reduced.

General Observations.—The temperature of the gas leaving the retorts showed a steady rise with the percentage of steaming, in the Yorkshire coal tests from 208 deg. C. with no steam to 427 deg. with 30 per cent. Rise of temperature was found often to accompany sticking of the charge in the retort, and in at least one test is thought to have been responsible for a poor yield of ammonia, but the regular rise seems to point to some thermo-chemical phenomena. At the same time the presence of at least 3 per cent. to 5 per cent. of steam is considered essential to preventing the bottom of the retort from getting too hot, for the increase of sensible heat carried off by the volatile products with increased steaming caused a fall of temperature at the bottom of the retort. It was, in fact, found necessary to reduce the external heat until the quantity of steam became more than the coke could decompose sufficiently without further heat from the combustion chambers. Incidentally this reduced the loss by radiation, but presumably not enough to vitiate the determination of radiation losses by the method described above.

The percentage of volatile matter in the coke, which was very low, was not affected by increased steaming, and in a normal throughput seems therefore to depend on the temperature of carbonisation.

The percentage of breeze in the coke—passing ¾-in. sieve—seems to have increased somewhat with increase of steam. At the same time the effect of steaming is said to have reduced the size of the pieces more than is indicated in actual breeze, and the friability of the Yorkshire coke was distinctly increased. On the other hand, the Durham coke, made from very small coal with large quantities of heavy dust, formed large pieces of very compact strong coke, suitable for light foundry work, whether produced with steam or without.

The retorts and settings were examined after 358 days' use, with steam supplied constantly except for very short periods to amounts that for most of the time had considerably exceeded 15 per cent. of the coal throughput. They were found to be in excellent condition, and to show no signs of erosion or wear through steaming.

Apart from economic considerations practical difficulties may put limits to the extent of steaming. There is for instance a limit to the conductivity of retort walls, and with strongly caking coals high percentages of steam—like, indeed, its complete absence—seem to increase the tendency of such coals to stick during carbonisation, and though this difficulty is said to be largely surmountable, the method recommended had not been tried at the station when the Board reported. Other coals, however, showed little or no sign of sticking through steaming in any percentage reached during the tests. It is thought probable that sticking, like difficulties with tar in the pipes, could be avoided by reducing the throughput, so as to prevent steaming from increasing the thermal output of the gas appreciably. This would, of course, be at a proportionate sacrifice of the capacity of the plant.

A separate problem from the determination of the optimum percentage of steaming is the improvement of the thermal efficiency of the setting itself. The station setting is doubtless more exposed to radiation losses than larger ones are, though as against this loss it has the benefit of its special and apparently effective preheater; but at all events, the order of magnitude of the loss in existing practice is suggested by the loss at the station, which, for a temperature of 1,260 deg. in the combustion chambers, varies from about 80 per cent. without steam to 67 per cent. with 30 per cent. steam. The extent to which a remedy can be sought by additional use of the flue gases for preheating the air is of course limited by either temperature in the case of a steel preheater, where the tubes cannot safely be heated much over 550 deg. C., and by size and weight with brickwork. Some form of lagging—perhaps thicker brickwork—is suggested as a possible help, and perhaps the use of flue gases for superheating steam if further experiment shows that superheated steam can be used in the retorts satisfactorily. Generally, too, the design of the retorts and their relation to the combustion chambers may be capable of improvement, and brickwork constructions might be substituted for many of the sight holes and other cast-iron and steel fittings on the walls of the retorts, damper access doors and the like. Important results have already been realised in this direction; but apparently much still remains to be done to reduce the loss of heat from the setting.

SHIPPING AMALGAMATION.—According to the *Danish Foreign Office Journal*, the shareholders of two Copenhagen steamship companies, the "Senta" and the "Pacific," have approved a scheme of amalgamation. For 1922 the Senta Company paid a dividend of 5 per cent. and the Pacific Company a dividend of 20 per cent.

NOTES.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.

THE fiftieth annual general meeting and conference of the Institution of Municipal and County Engineers was opened on Wednesday last at Leeds, when Mr. W. T. Lancashire, the city engineer of Leeds was installed as president and delivered his address. In it he traced the growth in membership and in importance of the Institution and the extension of its aims and objects. After briefly surveying the multifarious duties of a city engineer and their increase through the provisions of recent enactments, the president claimed that a great incentive to the more thorough training of young engineers had been given by the establishment of the scheme of examinations on the successful results at which entry to the Institution was decided. An address to the members was delivered on Thursday morning, by Sir Henry P. Maybury, the Director-General of the Roads Department of the Ministry of Transport, after which a series of papers on municipal works was read. The sewerage engineer of Leeds, Mr. G. A. Hart, described "The Leeds Sewage Disposal Works," Mr. G. Green, of Wolverhampton, gave a paper on "Model Bye-Laws, New Streets and Buildings," and Mr. T. Salkeld, the late chief engineer to the municipality of Delhi, described that Indian town and some of its engineering activities. A reception was given by the Lord Mayor of Leeds on Wednesday evening, and the annual dinner was held at the Queen's Hotel on Thursday evening. The meetings will be resumed this morning when an address is to be given by Mr. E. P. Hooley on "The Future of Others: Thrift or Drift," and the papers which are to be submitted comprise: "Town Planning, Housing and Reconstruction," by Messrs. J. E. Acfield and Mr. W. Dixon; "Developments in Tramways Track and Highways Construction," by Mr. E. W. Cockerlyne; and "Sea Defences of the South-East Coast of Devon," by Mr. S. Hutton. Many interesting visits to works complete the programme.

THE RUBBER INDUSTRY AND ITS PROBLEMS.

Addressing a special meeting of the Institution of the Rubber Industry last Monday, on "The Rubber Industry and its Problems," Dr. W. C. Geer, of the B. F. Goodrich Company, stated that the American output of rubber goods had increased 20-fold since 1899; and assuming that the American output represented three-quarters of the world's production, the value of that annual production would be 320,000,000*l*. Transportation, the foundation of civilisation, depended largely on rubber. Electric light and power distribution, the communication service, surgery and medical science and science generally relied upon rubber. America alone produced some 500,000 styles of rubber goods, and that variety put very heavy responsibilities upon the manufacturers who were expected to maintain quality and uniformity. Dr. Geer referred particularly to the motor car industry. They had in the United States 10,700,000 cars by January 1, 1923, last, and had now 12,250,000 cars; the number of cars in the world might total to 14,500,000. Thus the United States with 6 per cent. of the population of the globe, and 7 per cent. of its land, possessed 84 per cent. of the cars, one car for every 8·6 people, against one for 85 people in Great Britain and one for 42,000 people in China, the great market of the future. On the average a car required three tyres per year. By 1928 the world, now consuming 300,000 tons of rubber per year, would need 500,000 tons. There was no substitute for rubber. Could the rubber growers and manufacturers of America, Great Britain and other countries come together, guided by research, to eliminate ruinous competition and the production of inferior and unnecessary goods, for the benefit of all concerned? This appeal found strong support among the members of the Rubber Institution. Mr. Alexander Johnston, the chairman, had in introducing Dr. Geer, claimed the need of exceptional ability, judgment and courage for the rubber manufacturer who faced heavy responsibility in adopting any improvement. Without plantation rubber the industry could not have attained its growth, he remarked, but circumstances had enforced the adoption of a restriction

of the rubber production. If the industry should develop in the way suggested, the need of that restriction would disappear.

"CIMENT FONDU" FOR ROAD REPAIRS.

Considerable public attention has recently been directed to the question of road repairs in central London, and many complaints have been made about undue interference with traffic owing to the long periods during which roads have been closed, or partly closed. The question has no doubt been exaggerated both in the daily press and in Parliament, but none the less heavy repairs have in many cases taken a considerable time owing to the period which it has been necessary to give for the setting of Portland cement foundations. The general ventilation which this question had received adds interest to the work which has recently been done in the Borough of Holborn by Mr. E. F. Spurrell, the borough surveyor, in using "ciment fondu" for road repairs. This quick-setting, high alumina cement has been referred to more than once in our columns, and an account of its constitution and properties will be found in our issue of August 11 last. Briefly, the cement has the good qualities of Portland cement combined with remarkably quick-setting properties. These are illustrated by the work carried out by Mr. Spurrell. The cement was first tried in connection with trenches which had been opened in Endell-street, Shaftesbury-avenue, by the Post Office. Three trenches were dealt with and the cement was laid and completed by 10.30 one morning. The following morning Mr. Spurrell examined the work and found the surface exceedingly hard. To make sure, however, that the lower base was in the same condition he had one of the trenches cut out and the concrete blocks carefully examined. They were hard and in good condition and so generally satisfactory that the remaining trenches were asphalted immediately—that is within 24 hours of the concrete being laid. Last week work with "ciment fondu" was further extended and a large area of road in Guildford-street was laid with concrete made with the new cement. This was covered with 2 in. of compressed rock ashpalte the following day, and the road was immediately opened to traffic, which is heavy and includes a considerable coal traffic to the Hospital for Sick Children in Great Ormond-street. The price of "ciment fondu" is fairly high, approximating to some 6*l.* 10*s.* a ton, but the cost is compensated for by the savings in watching, lighting and public inconvenience, and it is to be hoped that the attention of many road authorities may be directed to work which has been carried out by Mr. Spurrell.

THE INSTITUTION OF GAS ENGINEERS.

The annual general meeting of the Institutio n was opened with an address of welcome from the Lord Mayor of Belfast in the City Hall, on Tuesday, June 26. The Birmingham medal was then presented to Mr. W. Doig Gibb, and afterwards Mr. James D. Smith delivered his presidential address. In it he traced the growth, during its century of operation, of the gas undertaking of Belfast, which is now under his charge. The papers submitted on Wednesday were on "The Flow of Gas in Pipes," by Mr. Stephen Lacey, and on "The Gasification of Coke in Steam, with Special Reference to Nitrogen and Sulphur," by Mr. Stuart Pexton and Professor J. W. Cobb. In his paper, Mr. Lacey brought together the theoretical groundwork of the subject of gas flow and gave the results of experimental investigations with small pipes. The second paper dealt with laboratory experiments from which it was deduced that the proportion of gasified nitrogen recovered as ammonia was dependent on the concentration of undecomposed steam in the exit gases and the temperature of gasification. Equivalence between the nitrogen gasified and the ammonia recovered was only obtained when large quantities of steam were used and the temperature of gasification was not above 900 deg. C. The maximum extent to which cokes could be desulphurised with little gasification of the carbon proved to be governed mainly by the proportion of sulphur existing as sulphide in the coke, but the use of high temperatures, which promoted rapid gas production masked the effect of the early liberation of the sulphur, and the use of steam in excess promoted independent liberation of sulphur, especially when the rate of gasification of the carbon was small. Professor W. B. Morton delivered a lecture on "The Flow of Gas," on Wednesday evening, at the Queen's University. The papers read on Thursday were on "Distribution in Belfast," by Mr. A. M'I. Cleland, and on "Ammonia Yields from Vertical Retorts," by Mr. George Braidwood. The experimental work conducted by the author of the second paper was of great interest. It showed that to obtain maximum yields of sulphate of ammonia, heavy steaming and moderate retort temperatures were essential and that the size of the carbonising material had very little, if any, effect.

SOCIETY OF GLASS TECHNOLOGY.

THE last ordinary meeting of the Society of Glass Technology, for the session 1922–23, was held in Leeds, on Wednesday, June 20, at 2.30 p.m. The first paper was presented by the president, Professor W. E. S. Turner, D.Sc., his subject being "*Specifications in the Glass Industry.*" Professor Turner pointed out that certain types of glass, such as that used for optical purposes, were bought on specification and had to conform very strictly to certain properties. In the enormous industry, however, which was concerned in the production of such things as containers for liquids and solids, no one seemed to have attempted to make or even purchase on the basis of specification. Several cases had arisen recently which had emphasised that lack of preciseness in the industry. For example, a fairly recent law case was fought round the quality of bottles supplied, and from the evidence given it was quite evident that, so long as the purchaser obtained something which had the shape of a bottle, the actual quality of the glass did not seem to have been specified. Several other cases of note had recently arisen, all pointing to the need of deciding to what specification different glass articles should conform. If the glass industry was to insist on furnace material makers providing refractories, for example, to specification, then the glass manufacturers themselves must at least show they were prepared to supply their own goods to specification. Professor Turner then dealt with specifications which he thought might be made the working basis for common articles such as medicine bottles, beverage bottles, and various other types of container.

The president, having to leave the meeting, the chair was taken by Mr. F. Lax (Messrs. Lax and Shaw, Limited).

Mr. Th. Teisen, B.Sc., then contributed some "*Notes on the Design of Pot Arches*," his remarks being illustrated by lantern slides.

Criticising the old type of pot arch, Mr. Teisen said the flue outlet for burnt gases at the back wall near the bottom, was certain to give cold pockets inside the furnace. On the other hand, the ensuing lack of proper heat distribution could be somewhat helped by longer soaking, which had a tendency to equalise the heat. The fire boxes being open, the fire itself was not under proper control. An experienced fireman, however, would endeavour to overcome this by his method of firing, which was by no means so simple as was commonly assumed.

The Continental type, with direct fired furnace, fire-box below, combustion flues and air flues leading to the uptake at the back of the chamber, and fumes passing through holes in the floor near the front and thence to the chimney was, he said, a better design; but the arranging of it in the glass-house was not so practical. With the entry of the gas-fired pot furnace in the glass industry, a demand had arisen for a more modern type for heating pots. That type should contain better facilities for heat distribution and control; it should also combine good conditions for working and firing with easy installation and economy of space. Mr. Teisen then described a gas-fired recuperative pot-arch, which he designed on those lines some years ago, and which proved a success. He also described a pot-arch at work at Messrs. Moncrieff's works at Perth, where during the first stage of burning, a low fire was kept on the grate, fed through the ash door. The secondary air slide was closed, and the furnace was in other ways directly fired. For the purpose of driving out the natural and the combined water without producing surface cracks, water was kept dripping on the fire-bars, as well as on a plate arranged in front of them, thereby producing a certain amount of steam, which helped to retard a too quick drying of the surface parts and allowed the inside to evaporate its moisture at the same rate as the outside. The pot walls, in other words, sweated the moisture out. The steam produced made it necessary to run with the usual density of smoke. That type took up little space with proportionately less building cost, and results in practice were quite satisfactory.

Mr. S. English, M.Sc., followed with a paper entitled "*Notes on the Ashley Bottle Machine.*" Mr. English remarked that to one familiar only with modern glass-forming machines, it might be surprising to hear that the home of bottle-making machinery was on this side of the Atlantic, but such was the case, and it was only after the possibility of making narrow-mouth bottles satisfactorily by machines had been proved here, that such bottle-making machinery was introduced in America. The first machine to make narrow-mouth bottles at all satisfactorily was designed and built by Mr. H. M. Ashley, at Ferrybridge (Yorkshire), and it came to be developed in the following way. About 1886, the postmaster at Ferrybridge, Josiah Arnall, naturally had occasion to go to the bottle works which were situated within his district, and after seeing the way in which bottles were gathered, marvered and blown, he conceived an idea, which he thought if developed, would enable bottles to be blown by machinery. He submitted his idea to a prominent South Yorkshire bottle manufacturer, but apparently it was too crude or too revolutionary to be taken up. Nearly twenty years later, Mr. H. M. Ashley, the manager of an iron foundry near the post office, went to live with Arnall, and there can be no doubt that Arnall discussed with Ashley his ideas concerning the possibility of blowing bottles by machinery.

As a result of such discussion, Ashley built an experimental machine in which glass was poured into an inverted mould, which was fitted with a plug to form the inside of the neck and with a movable top plunger. When a charge of glass had been placed in the mould, the sliding plunger was brought down on top of it, thus pressing it down around the fixed plug and forming the neck. Compressed air was then admitted through the plug, blowing up the bottle and at the same time raising the sliding plunger, to the desired extent. Such an arrangement was very simple, and was naturally unsuccessful, but it had sufficient good points to cause Ashley to try to develop it into a useful machine. The first step in its improvement appeared to have been an appreciation of the fact that three moulds were necessary, one for forming the neck of the bottle, the second for giving a preliminary form to the main body of the glass, and the third for blowing the finished bottle. This provision of a ring mould, parison mould and blow mould was the foundation on which all Ashley's experimental machines were built, and has been incorporated in every successful machine since.

The president intimated that, through the co-operation of Mons. Delloye (Glaceries de St. Gobain), an interesting programme had been arranged for the visit to France during the first week of July.

"YIELD-POINT OF STEEL UNDER TRANSVERSE STRESS."

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to Sir Alexander Kennedy's paper, in your issue of the 15th inst., in which actual cross-bending results of solid sections are considered, of the two explanations of strength increment suggested, viz., the advantage derived by the more seriously deformed layers from those less affected, and supposition of a stress area greater than that which obtains with proportional strain, I have been accustomed to favour the latter, though it now appears that the first-named has a considerable influence. If we make the extreme assumption that the bar approaching failure is stressed well beyond the yield-point in tension and compression right up to the neutral axis, we shall have a condition in which the stress developed will, for ductile material, not greatly differ from uniformity. Following up this supposition, I find that the resulting modulus in any case differs greatly from the modulus derived on the elastic basis. To give examples:—

	Normal Modulus.	Amended Modulus.	Ratio.
■ – Square on side ...	$\frac{b^3}{6}$	$\frac{b^3}{4}$	1 to 1·5
◆ – Square on edge ...	$\frac{b^3}{8\cdot5}$	$\frac{b^3}{4\cdot25}$	1 to 2·0
● – Round	$\frac{\pi d^3}{32}$	$\frac{\pi d^3}{18\cdot9}$	1 to 1·7

I offer no demonstration of the amended values as they may be readily verified. It will be observed that the results for the square section on its side, or on its edge compare fairly well with the experimental results for the steel tested considering that the tests were carried no further than the yield-point. This treatment in no sense meets strict mathematical requirements, but furnishes a ready practical method of dealing with such sections. I should hesitate, however, to use it for cast-iron in which the tensile and compressive areas cannot be regarded as behaving similarly up to breaking point, in which the resistance to compression is so much greater than in tension, giving a stress area for compression still following elastic law, while that for tension has materially departed from it—with displacement of the neutral axis towards the compression edge. The difference in test results accompanying difference in the method of loading is certainly in support of Sir Alexander's original suggestion; possibly light might be thrown upon the matter by a study of rectangular tension test-pieces, under eccentric loading, for elastic conditions giving, say, zero stress on one edge and twice the mean stress on the other, which when pulled should give significant results.

Yours truly,
W. H. THORPE.

12, Buckingham-street, Strand, London, W.C. 2.
June 23, 1923.

JUBILEE EXHIBITION IN GOTHENBURG.

TO THE EDITOR OF ENGINEERING.

SIR,—In connection with the above exhibition a series of meetings is to be held in Gothenburg, Sweden, as follows:—August 13, meeting of General Shipping Society, of Sweden; August 14, meeting of Swedish Societies of Naval Architects; August 15, meeting of Committee Maritime International; August 16, meeting of Society of Northern Shipowners; August 17, meeting of Society of Swedish Shipowners; August 18, meeting of Society of Swedish Shipmasters.

Any members of the Institution of Naval Architects who desire to attend the above meetings will, I am informed, be welcome and should communicate as soon

as possible with the secretary: Captain Olof Traung, The Maritime Museum, Gothenburg (Sweden), who will arrange for rooms and cards of admission to the exhibition and meetings.

Yours faithfully,
R. W. DANA,
Secretary of the Institution of Naval Architects.

"GRAPHICAL TRIM CALCULATIONS AND A TRIM NOMOGRAM."

TO THE EDITOR OF ENGINEERING.

SIR,—I have been reading the paper by Mr. E. V. Telfer, M.Sc., entitled "Graphical Trim Calculations and a Trim Nomogram," read at the spring meeting of the Institution of Naval Architects, March 23, 1923, published on page 565 of ENGINEERING, May 4, 1923, which I find very interesting. I am unable, however, to show that

$$f(a) = \frac{a}{12\,(3-2\,a)},$$

and should be exceedingly obliged to you if you could give me any assistance in the matter. Thanking you very much in anticipation.

Believe me, yours faithfully,
CARLOS PREYSLER.

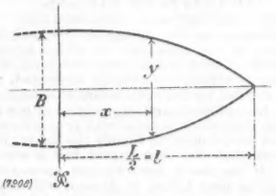
Sagasta 25, Madrid, June 9, 1923.

We forwarded the above letter to Mr. Telfer, the author of the paper, and he sends the following reply:—

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Preysler's reference to my recent paper read before the Institution of Naval Architects has interested me greatly. The approximate formula for the longitudinal moment of inertia coefficient, which I included in that paper may be established as follows:—

Assume the vessel's water plane to be parabolic and symmetrical about 'midships.



Thus, as is shown in figure, with origin at 'midships the ordinate y at a distance x may be expressed as

$$y = B\left(1 - \frac{x^n}{l^n}\right) \quad . \quad . \quad . \quad (1)$$

The total area of the water plane thus becomes on integrating:

$$\int_o^2 y\,dx = 2\,B\left[x - \frac{x^{n+1}}{l^n\,(n+1)}\right]_o^l = 2\,B\left[l - \frac{l}{n+1}\right]$$

$$= B\,.\,L\,\frac{n}{n+1}$$

but the area is also equal to B . L . a, a being the water-plane area coefficient. Therefore

$$a = \frac{n}{n+1}$$

and hence

$$n = \frac{a}{1-a} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The moment of inertia about 'midships may be expressed as

$$\text{M of I} = 2\int_o^l y\,x^2\,dx = 2\,B\int_o^l \left(1 - \frac{x^n}{l^n}\right) x^2\,dx$$

$$= 2\,B\int_o^l \left(x^2 - \frac{x^{n+2}}{l^n}\right) dx$$

$$= 2\,B\left[\frac{x^3}{3} - \frac{x^{n+3}}{l^n\,(n+3)}\right]_o^l = 2\,B\left(\frac{l^3}{3} - \frac{l^3}{n+3}\right)$$

which, in terms of L, reduces to

$$\frac{B\,.\,L^3}{12}\,.\,\frac{n}{n+3},$$

but as $n = \frac{a}{1-a}$, the foregoing expression further reduces on substitution, to

$$\frac{B\,L^3}{12}\,.\,\frac{a}{3-2\,a} \quad . \quad . \quad . \quad (3)$$

Comparing this expression with the more general one,

$$\text{M of I} = f(a)\,B\,.\,L^3$$

we see that finally

$$f(a) = \frac{a}{12\,(3-a)}$$

Q. E. D.

So far as I am aware, the above formula is original. However, the very useful analytical assumption of parabolic water planes which forms the basis of my analysis is by no means new. It was first introduced by Chapman towards the close of the eighteenth century.

Yours faithfully,
E. V. TELFER.

22, Lovaine-crescent, Newcastle-on-Tyne,
June 19, 1923.

"THE USE OF STEAM AT EXTREMELY HIGH PRESSURE."

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to your editorial "The Use of Steam at Extremely High Pressure," appearing in your publication of the 22nd inst., I take it that your article was inspired following on the subject-matter appearing in the two issues of the American journal *Power*, dated May 22 and 29. Generally your article, in so far as it affects this company, defines approximately the position, but I should be obliged if you would allow me the following comments.

In your column (1) the statement is made that "the theoretical increase with increase of pressure is not very great." Exactly what is considered as not very great? *Power* diagrammatically illustrates cycle efficiencies for varying pressures with and without superheat, by small-scale temperature-entropy charts. These results tabulated, read as follows:—

For dry saturated steam without any superheat whatever,

Pressure, lb. per sq. in.	200	500	1,500	3,200
Theoretical efficiency per cent. ...	31·6	36·0	39·8	37·8
Corresponding fuel consumption, per cent.	100	87·8	79·4	83·6

In a super-power station, this difference in efficiency between 200 lb. and 1,500 lb. per square inch would represent an enormous saving in fuel in favour of the latter pressure. By superheating at the higher pressure to a total temperature of 900 deg. F., and to a corresponding lower temperature for the lower pressure, an even greater saving could be effected.

In your column (2) the theoretical efficiency of a cycle of 500 lb. per square inch, dry saturated steam is calculated as 35·3 per cent. and a cycle of 200 lb. per square inch as 31·96 per cent. Even with these conditions, which would never be accepted in practice without considerable superheating at the higher pressure and consequent further improvement in efficiency, the theoretical gain with steam at 500 lb. per square inch is about 10 per cent., which still represents a considerable saving in fuel. The efficiency with steam at 2,400 lb. per square inch, given as 41·78 per cent., would represent a gain that any station engineer would certainly welcome, as it would reduce his fuel bill by about 23½ per cent.

A comparison in theoretical efficiency is herewith made between low-pressure and high-pressure plant operating under what would be the best conditions of pressure and temperature. Steam at 200 lb. per square inch, total temperature 607 deg. F., 29-in. vacuum, theoretical efficiency 32·1 per cent. Steam at 2,000 lb. per square inch, total temperature 900 deg. F., theoretical efficiency 42·5 per cent. That is, a gain at 2,000 lb. per square inch, of 24½ per cent. in fuel consumption.

Again in the same column (2) the statement is made that a temperature of about 700 deg. F., may be taken as the highest practicable. As you have referred to the Babcock and Wilcox water-tube boiler now being built for Weymouth, U.S.A., it might be here observed that this boiler will be designed to superheat steam up to 750 deg. F., and to hold a pressure of 1,200 lb. per square inch, at this temperature, in a header apparently about 10 in. diameter, the steam drum being 4 ft. diameter and 4 in. thick. With metals procurable to-day and due to the very small internal sections of our heating elements, it is considered that a temperature between 800 deg. and 900 deg. F. can be safely obtained and controlled.

We are not alone in this belief, as the super-high-pressure turbines contemplated to-day are designed for temperatures higher than 700 deg. F. It is perhaps not sufficiently appreciated that this matter is one of universal interest as evidenced by the number of well-known turbine manufacturers who have seriously undertaken the construction of super-high-pressure turbine plant and contracts, even now, have actually been placed for turbines to operate with steam at or above 1,000 lb. per square inch. It is highly desirable that when operating with steam pressures in the neighbourhood of 2,000 lb. per square inch, that the steam be superheated to a total temperature of about 840 deg. F., and it is possible, with suitable re-heating, to obtain a theoretical efficiency of 47·5 per cent. under these conditions. With a large size unit the actual overall thermal efficiency should be in the neighbourhood of 28·8 per cent., not considering the power lost by the auxiliaries, or 27 per cent. net with auxiliaries.

Modern steam plant power stations, operating with steam pressures of 400 lb. and less, show a net overall thermal efficiency of not more than 20 per cent., so that the actual saving between the plant at 2,000 lb. per square inch and one of less than 400 lb. per square inch, should be 25 per cent., which even to-day might be considered revolutionary. Assuming that a saving of 15 per cent. could be obtained on a super-power station of a total capacity of 200,000 kw., with a continuous load factor of 40 per cent., then the saving in fuel would be in the neighbourhood of 63,000*l.* per annum with fuel at 1*l.* per ton. This amount capitalised would warrant the expenditure of about 600,000*l.*, to secure this saving. Quoting from *Power* of August 1, 1922, the statement was made regarding Gennevillers station of 320,000 kw. capacity "that a 1 per cent. saving in the coal consumption would result in a yearly saving of 45,000 dols., and that this saving would warrant the expenditure of more than 250,000 dols. for equipment necessary to secure this 1 per cent. saving." These figures speak for themselves and illustrate the importance of even only a small increase in the overall thermal efficiency of a large steam power plant.

The plant which we are erecting at Rugby, through the kindness of Messrs. English Electric Company, Limited, who are interested solely in the turbine end, will be built with two main points in view: (1) To demonstrate the theory and to obtain data to construct a larger plant on commercial lines; (2) simplicity and safety. On a commercial plant, therefore, the feed water instead of entering the generator at, say, 100 deg. to 150 deg. F., will most probably be heated to a temperature of about 250 deg. F., by bleeding the low-pressure turbine. The temperature of the fluid in the generator heater itself must be raised higher than 706 deg. F. (the critical point), otherwise, on throttling down to 1,500 lb. per square inch, the fluid would return to a partial liquid state. It is therefore intended to heat the fluid in the heating elements, at a pressure of 3,200 lb. per square inch, to a temperature corresponding to about 1,130 B.Th.U., before throttling to 1,500 lb. per square inch. This would ensure a slightly superheated steam at 1,500 lb. per square inch. In the test plant the temperature will then be raised to about 788 deg. F. in the generator superheater. This working cycle diagram is clearly illustrated in the edition of *Power* of May 29, in the small scale total heat entropy chart.

I enclose herewith skeleton cycle diagrams showing the theoretical efficiency of a proposed plant operating at 1,500 lb. and alternatively 2,000 lb. per square inch. With feed water assumed as 200 deg. F., the theoretical efficiencies would be 46·2 per cent. and 47·5 per cent. respectively.

I would like to draw your attention to an apparent error in the calculations given as those of Professor Callendar. The heat available for the test high-pressure turbine is stated as being 166 B.Th.U., the heat available for the low-pressure turbine being 425 B.Th.U. Therefore the heat available for working the two turbines is 166 plus 425, which is 591 B.Th.U., and not 571 B.Th.U. as stated. No reductions from this amount should be made, as only theoretical efficiencies are being considered. The theoretical efficiency then should read 40·2 per cent., and not 38·8 per cent. The theoretical efficiency of the low-pressure turbine, 32·5 per cent., is agreed, and taking the theoretical efficiency of the high and low-pressure turbines as 40·2 per cent., this difference, *i.e.*, 19 per cent., quite contrary to the suggestion, is certainly very striking when one remembers the enormous saving effected by an improvement of only 1 per cent. Under better conditions of pressure and temperature for the super-high-pressure turbine, the difference in thermal efficiency would be more than 19 per cent., as already shown.

The points which I have endeavoured to make clear in this letter are, that the material gains with super-high pressures are so considerable that, granting the possibility of the thermal efficiency of the high-pressure turbine being not more than 50 per cent., even so, this would not result in any great reduction in the net overall thermal efficiency, and we confidently look forward to effecting a saving in fuel of at least 15 per cent., which is considerably less than that calculated. The question of governing the prime movers does not offer any insuperable difficulty, and various arrangements suggest themselves, particularly for very large units.

Yours faithfully,
BENSON ENGINEERING COMPANY, LIMITED,
W. A. JOHNSTON, Chief Engineer.
109, Kingsway, London, W.C. 2, June 26, 1923.

[Our article was not "inspired" by anybody, but was obviously suggested by the publicity given to the activities of the Benson Engineering Company by our contemporary *Power*. It was written in order to place before our readers as succinctly as possible the limits of efficiency theoretically obtainable with steam at very high pressures, and had we been indebted in any way to our esteemed contemporary for any of our calculations or results we should, of course, have made due acknowledgment. Since our correspondent admits that our article "defines approximately the position" there is little room for discussion. The theoretical efficiency of any cycle is simply a matter of calculation and Callendar's tables provide accurate data for the purpose. Whether the increase of possible efficiency from 33·8 per cent. to 43·3 per cent. as calculated in our article, is large as compared with the corresponding increase of pressure from 200 lb. to 2,400 lb. per square inch, is a matter of opinion. We must however particularly demur to our correspondent's suggestion, that the actual fuel consumption of a plant must be in proportion to the theoretical efficiency of the heat cycle adopted. A turbine can only be designed to turn into work a certain proportion of the available heat energy, and this proportion may be less with high-pressure than with low-pressure steam on account of the inevitable losses. If, to take an extreme case, an efficiency ratio of 56 per cent. were all that could be attained by a turbine plant working on a cycle of 40 per cent. efficiency, the steam consumption of that turbine would be actually greater than if it worked with an efficiency ratio of 75 per cent. on a cycle of only 30 per cent. efficiency.

With regard to Professor Callendar's figures, our correspondent has overlooked the work required to pump a pound of water into a boiler at 3,200 lb. pressure. Taking this, as Professor Callendar did, as equivalent to 10 B.Th.U., we get a net theoretical available work of (166 + 425 − 10) = 581 B.Th.U. The theoretical efficiency of the whole cycle is therefore 581 ÷ 1,471 = 39·5 per cent., which though greater by 0·7 per cent. than the figure we gave, is less by an equal amount than the figure which our correspondent arrives at. We are, however, obliged to him for pointing out the fractional inaccuracy in the figures as published.

We wish the Rugby experiment every success, and hope that when the plant is built and operating we shall hear of results which justify so bold and interesting a departure from accepted practice.—ED.E.]

WATER-TUBE BOILER AND CRANE CONSTRUCTION.

Fig. 1. BABCOCK & WILCOX BOILER WITH SUPERPOSED WATER ECONOMIZER.

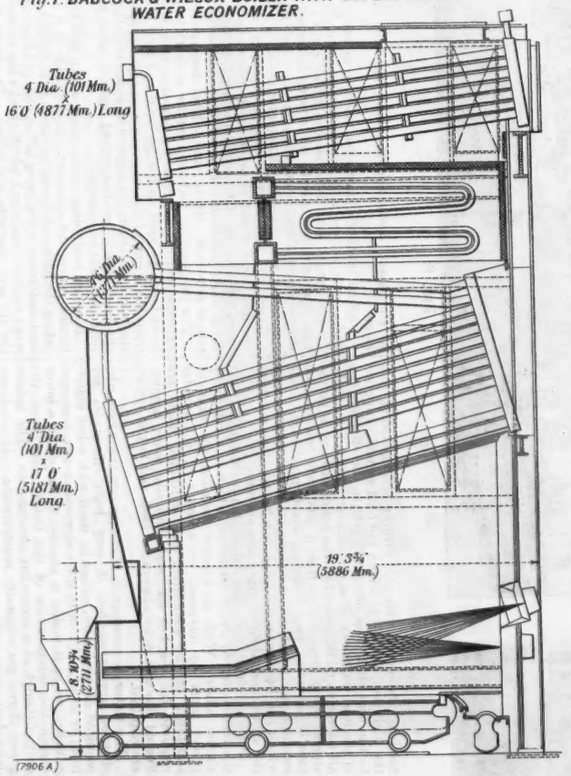


Fig. 2. BABCOCK & WILCOX BOILER WITH INTEGRAL AIR HEATER

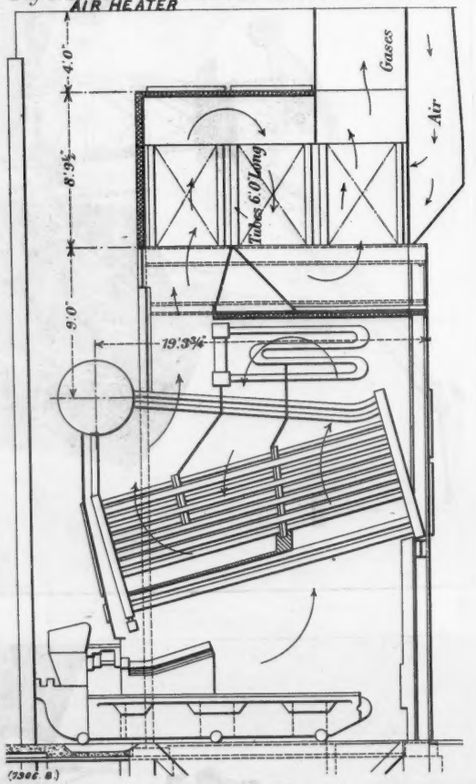
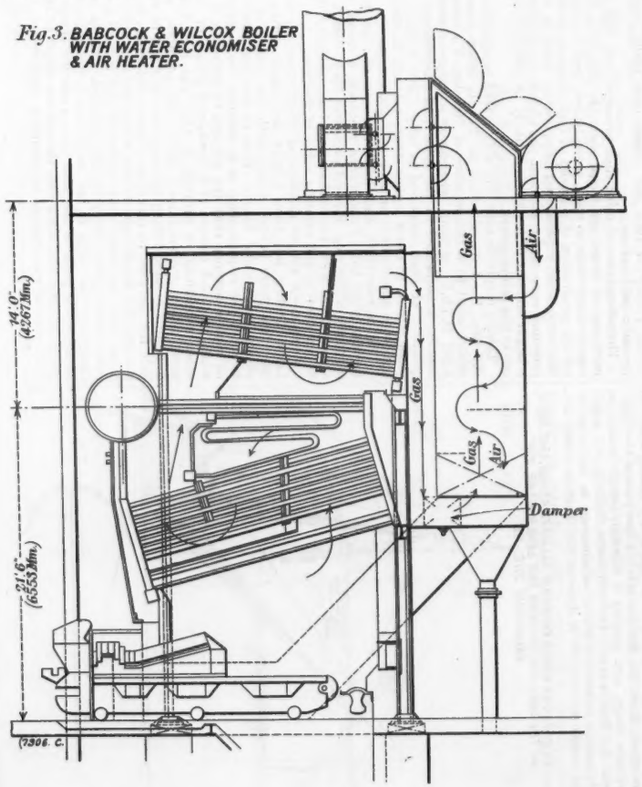


Fig. 3. BABCOCK & WILCOX BOILER WITH WATER ECONOMISER & AIR HEATER.



WATER-TUBE BOILER AND CRANE CONSTRUCTION.*

By Sir JAMES H. R. KEMNAL, F.R.S.E., of London, Member.

THE idea which gave rise to the invention of the water-tube boiler dates back more than a century. Examples of efforts in this direction are found as far back as 1796, in a boiler originating with Count Rumford, under whose directions boilers were made for the lecture room of the Royal Institution, in which the water was divided up into comparatively small cylinders. In 1805 a boiler invented by John Cox Stevens, an American engineer—which was really a shell containing a large number of water tubes—was put into use. In 1815 a boiler was designed by Trevithick on similar lines to Count Rumford's boiler, in which some of the small cylindrical vessels were closed at one end, and hanging from a receiver, vertically.

In 1825 the first design appeared in which the steam generating portion of the boiler consisted entirely of tubes, and in 1856 a boiler was made by Stephen Wilcox, one of the originators of the firm of Babcock and Wilcox, Limited, which appears to have been the forerunner of the early designs of the Babcock and Wilcox boiler.

Whilst before 1880 the design was brought in appearance and on general lines into a resemblance of the present-day design, and many installations of it were carried out in America before 1880, it was not until this time that it made its appearance in Great Britain; one of the first important installations with which the author was connected was carried out in 1882, and consisted of 10 boilers for Messrs. David Colville's steel works—which, it may be incidentally mentioned, are still in operation. The boiler was then made with cast-iron headers and mud-drums, and the steam drumheads were likewise of cast-iron—the cast-iron being a specially strong mixture—and in those days pressures were rarely above 120 lb. per square inch.

In 1882 the boiler was used for the first electric light plant for public incandescent lighting—that of the Edison Company in Holborn Viaduct; and just as electrical engineers are the most progressive and sympathetic to an innovation at the present time, so they were amongst the first to appreciate the merit of the design in those days. The boiler rapidly grew in favour, and it was not long before the construction required altering in detail to meet higher pressures, and works required to be built for manufacturing it on a larger scale.

The opposition to the use of the boiler, made by the makers of shell boilers, which was very great, need not be gone into, but the criticisms led to improvements, amongst which the most notable was the substitution of wrought-steel for the cast-iron, for which the inventing of special machinery was necessary; and the nucleus of the present works was established in 1895. From this date onwards the boiler grew in favour, and began to spread itself in other parts of the world.

In 1901 a design of it was evolved for use in marine work, and in that year it was first successfully employed for such service. The British Navy adopted it after the well-known investigations that were carried out by a Royal Committee in 1904, and it was installed by the Admiralty in a large number of vessels. Unfortunately, many of these vessels have been scrapped under the new naval agreement, but such vessels as the Renown, Tiger and Queen Elizabeth still exist. A great many ships fitted with the boilers took part in the great war and the record of the boilers, under the exigencies of war service, was entirely satisfactory.

It is noteworthy that at the present time it is used in the mercantile marine for all classes of vessels from a steam tug to an Atlantic liner, and its position has been thoroughly established. The use of water-tube boilers has now become so general that the British Marine Engineering Design and Construction Committee were called upon to propose regulations for their construction, and this has resulted in the establishment by the Board of Trade, and the leading marine survey bodies, of official rules governing details of construction.

Considerable controversy has existed, alike in the application of water-tube boilers for marine purposes, and for stationary purposes, over the question of whether the principle of having the tubes inclined say, 15 deg. from the horizontal, or inclined 80 deg. to 90 deg. as in boilers called vertical tube boilers, was the better. In the former there is solid water, or as near solid as water ever is in a boiler under steam, inside the tubes on the fire side, and the steam produced inclines to the top side. In the vertical tube boiler, however, there is a geyser-like action, in which the mixture of steam and water in the tube is equal nearest the fire to what it is farthest away from the fire. In the author's experience the result with the former, as regards durability, is superior to the latter, and there is no such advantage as is pretended for the vertical tube boiler in circulation, nor is the circulation in any way better, but, on the contrary, it is not so good. In the vertical tube boiler experience has shown that when steam is raised the lower drums, that are not exposed to the fire, are cold, thus repeating the same experience that exists with the cylindrical boiler, that when steam is raised the bottom of the boiler is cold, which condition continues until the

* Paper read before the Institution of Mechanical Engineers at Glasgow, June, 1923.

stop valve is opened, thus setting up strains that are detrimental.

Another point that bids fair to be controversial is that of air heaters *versus* economisers. Apparatus for slightly heating the air for combustion has been used for many years in marine work with Howden's forced draught, and recently the use of similar apparatus is extending to important stationary plants. It may be said that for stationary plants the application of both economisers and air-heaters is a considerable source of economy, and enables smaller boilers to be used for a given duty. In marine work economisers are not generally used, but the application of air-heaters is very useful.

The theories underlying the application of both these appliances are the following :—

The addition of an economiser to a boiler and superheater permits of the utilisation of a larger proportion of the heat of the fuel. The effect of a water economiser containing about 50 per cent. of the boiler surface is to increase the work done—that is, the output for a given quantity of fuel, about 8 per cent., corresponding to an increase of about six points in the efficiency percentage, bringing this up to about 82 per cent., based on the higher calorific value—or 88 per cent. on the lower value.

If an air-heater be added to a boiler in lieu of a water economiser, then to obtain the same increase of output, namely 8 per cent., the boiler surface must be increased 8 per cent., because in the case of the air-heater the additional heat recuperated must be absorbed in the boiler surface itself. With this increased surface, and with the boilers worked at about the usual rate as when economisers are fitted, there would result about the same gas temperature at the outlet from the boiler, namely, 600 deg. F. to 650 deg. F., as with the water economiser ; but if this heat has to be utilised in an air-heater, whilst retaining the same final gas temperature in the boiler, it would result in a high temperature in the air delivered to the furnace, which probably would affect the durability of the furnace material. In such cases, therefore, if an air-heater alone is to be fitted, an addition to the boiler surface is desirable to effect a reduction in the temperature at the outlet from the boiler, so as not to raise the air temperature too high by the air-heater. This would mean a further increase in boiler surface of roughly 10 per cent. to 12 per cent. Hence the total increase in boiler surface if an air-heater be fitted instead of an economiser, under ordinary conditions should be 15 per cent. to 20 per cent., and the air-heater then required would have about 130 per cent. to 150 per cent. of the boiler surface. The result would be an increase in temperature of the air to about 240 deg. F. to 250 deg. F., and an outlet gas temperature from the air-heater about the same as would be obtained from a water economiser, and the efficiency of the unit would be about the same.

In regard to fitting an air-heater in addition to an economiser with the object of obtaining a further increase of efficiency by lowering the final gas temperature leaving the unit, it may be assumed that the ordinary final escaping gas temperature from boiler and economiser is about 350 deg. F. to 400 deg. F., and if this is to be reduced by about 100 deg. the increase obtainable in efficiency would be about 2½ per cent., and the air would be correspondingly heated about 100 deg. F. To do this an air-heater of about 100 per cent. of the boiler surface would be required. Figs. 1, 2, and 3 illustrate Babcock and Wilcox boilers, showing water economisers, and air-heaters singly and in combination.

The practice is now becoming common of increasing the temperature of the feed supply by taking some of the steam from the turbine after it has passed the high-pressure stage, and passing it through steam-heaters to heat the feed water. In such cases there is not much advantage in using a water economiser, as the work of the water economiser is done in the heaters which are used in connection with the turbine arrangements, and the high temperature at which the feed water is supplied to the unit then does not lend itself to the effective use of the feed water heater or economiser ; in such cases the air heater alone is preferable, the boiler surface, as stated above, being arranged so that a moderate transmission rate is provided, thus reducing the temperature of the escaping gas from the boiler to such a point that the heat which can be abstracted in the air-heater does not heat the air to more than a reasonable amount.

With water economisers a desirable feature is to treat the feed-water to avoid corrosion, which is a relatively simple affair. With air-heaters installed the draught power must be increased on account of the greater resistance of the air-heater, and additional ducts are required for the hot air and naturally more lagging. Forced draught must always be used and larger boilers are required.

The water economiser is, therefore, on the whole, the cheaper apparatus, but if very high efficiencies are required an air-heater, either by itself with a hot boiler-feed, or as an addition to the water economiser, possesses advantages, as it makes it possible to reduce to a lower degree the temperature of the outlet gases from the unit, although at a somewhat greater cost. The figures given above are naturally approximate only, and are dependent upon rating, steam pressures, feed temperatures, quality of fuel, &c. Each case really requires special consideration.

The advantages of using high pressures and high temperatures of steam are based upon the fact that, when superheated steam is used, actually less heat is required for the production of a pound of high pressure steam to the same final superheated temperature than if lower pressures were used ; and with the higher steam pressure, a larger amount of work can actually be obtained by its use in the prime mover.

Taking a specific case, say with a feed temperature of 100 deg. F., 1 lb. of steam at 200 lb. gauge-pressure, superheated to a temperature of 700 deg. F., contains 1,297 B.Th.U. of heat, whereas at a gauge-pressure of 350 lb., superheated to the same final temperature, the quantity of heat contained is only 1,290 B.Th.U. In other words, to use a higher steam pressure in conjunction with superheat is an economic advantage.

The introduction and improvements of the steam turbine have led to conditions requiring a steam temperature of 700 deg. F., and pressures up to 500 lb. per square inch, with the realisation of an efficiency up to 88 per cent. of the calorific value of the fuel.

Cranes.—A simple mechanical contrivance known as Lever Luffing has been largely developed during the past few years in connection with the luffing of jibs, sheers, and boats' davits. One of the first essentials to meet the requirements is to arrange the mechanism in such a manner that the jib can be luffed in or out while the load travels in a horizontal plane, or under some conditions to arrange so that the load follows some other predetermined path. For instance, when designing a rapid luffing jib-crane it might not be desirable for the load to travel in a horizontal plane, but to rise rapidly when approaching the maximum and minimum radii, so that further outward and inward movement of the jib is automatically arrested. Again, when designing sheer-legs it has been found desirable to so arrange the path of the load that while the sheers are going out the load shall rise, the objects aimed at being, first, general convenience in handling, and second, relief of the heavy stresses in the back leg and traversing screw.

Various methods have been tried to accomplish these ends, such as the well-known arrangement of the old Scotch derrick with two barrels, which can be clutched together, so that while the jib is being luffed inwards the load is automatically lowered and *vice versa*, thus maintaining an approximately horizontal path.

There are also various arrangements for passing the hoisting rope round sheaves, with the same object in view, but serious drawbacks have been discovered in all these older methods. Lever luffing meets the requirements previously stated, and a brief description follows.

The jib (see Fig. 4 above), carries a short lever at its extreme end, over which the hoisting rope passes, the lever being pivoted on the jib head and held in position from the frame of the crane by wire-ropes passing round the tail of the lever, the ropes thus automatically working the lever in any predetermined manner when the jib is luffed inwards or outwards.

It is the designing of this lever which will be of particular interest to members. In the figure is a line indicating the horizontal path in which it is desired that the load shall travel while being luffed, the path showing an upward curve at each end which checks the momentum of the jib and prevents overluffing. To obtain the shape of the tail of the lever round which the rope passes it

Fig. 4. COMBINED DIAGRAM ILLUSTRATING THE PATH OF THE LOAD AND SHOWING THE LEVER GEAR FOR BALANCING THE JIB.

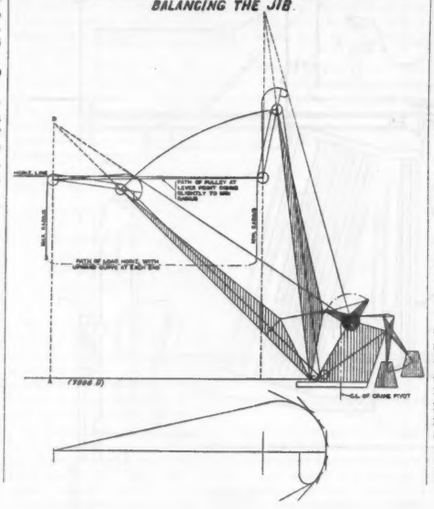


FIG. 5.

FIG. 6.

will be seen that a vertical line AB is drawn through the point of the lever, and another line BC through the centre of the jib. From the point of intersection of these two lines a third line BD is drawn to the point at which the back guys are attached to the frame of the crane. This forms the tangent from the fulcrum of the lever and gives one point in the path. If this operation is carried out at various points between the maximum and minimum radius the curve at the tail of the lever round which the back guy rope has to pass will be formed.

A further development in connection with lever luffing is the balancing of the weight of the jib, shown in the figure, which is accomplished by means of a swinging weight carried on levers on the back of the revolving portion of crane and connected with the jib in such a manner that as the jib and load travel out this weight also travels out in the opposite direction and *vice versa*. The system of balancing is a later development and is of special interest because, in addition to balancing the jib, it counteracts the shock to the structure so prominently present when an unbalanced jib is in operation. The balancing is accomplished by a swinging weight transmitting through a system of levers it counterbalancing effect of the jib.

Figs. 5 and 6 illustrate a dockside crane, fitted with lever luffing, at its minimum and maximum radius.

In connection with sheer legs it will be seen from what has already been said that a lever can be fitted so that a set of sheer legs can be made to carry as heavy a load as they were originally designed for, at a far greater radius, because a large portion of the loadings can be taken by means of the guys from the lever to a concrete mooring instead of carrying it through the back leg. By making use of this idea the 100-ton sheer legs, Fig. 7, has been fitted with a lever, enabling it to carry its full load at an increased radius of 25 ft., without putting additional stresses into the legs.

The latest development of this design is called the jib lever-transporter, Fig. 8, and it has the appearance of a lever jib-crane, but is so designed that the load hanging on the lever passes through the jib, so that when unloading from a ship to a point inshore the load can travel in a straight line instead of in a circle, as in the case of an ordinary jib-crane. The principles on which this transporter is designed are exactly the same as for the ordinary lever jib crane already described, while it is counterbalanced by the same methods, but it can readily be seen that it is a far more rapid means of unloading than the ordinary jib-crane.

The principle has also been applied with success to ships' davits for large Atlantic liners. In Fig. 9 will be seen davits on the T.S.S. Empress of Canada. In this case there are two lever jibs spread apart a sufficient distance to enable the boats to pass in between them, and the jib-lever operates on both sides of the vertical so that boats can be transferred from any desired point, across the ship, and lowered into the water, either to starboard or port.

Fig. 7. DIAGRAM OF SHEER LEGS FITTED WITH LEVER.

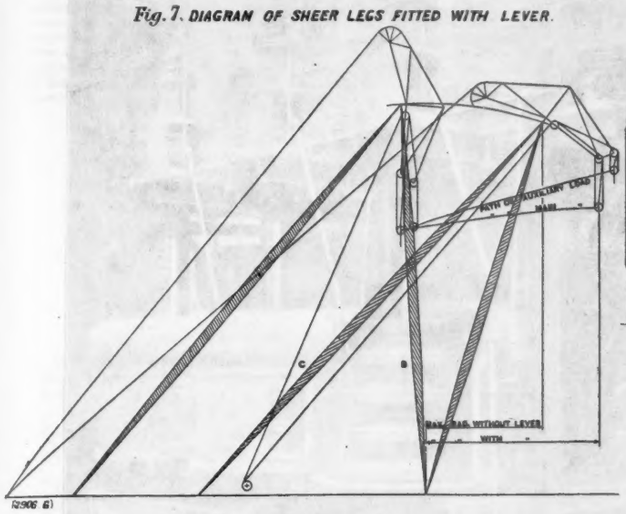
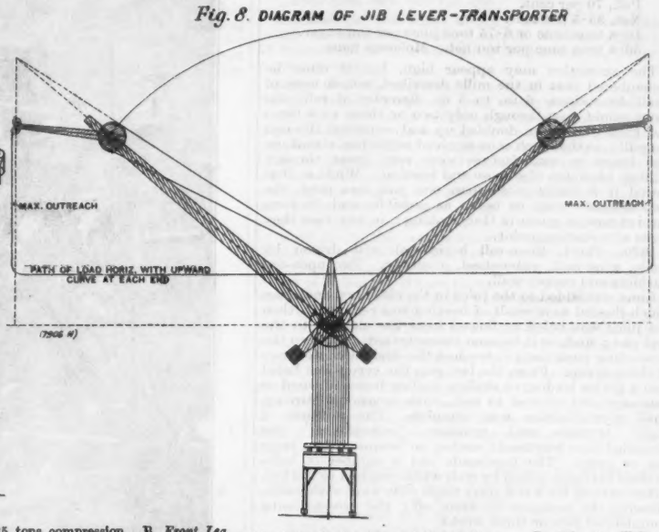


Fig. 8. DIAGRAM OF JIB LEVER-TRANSPORTER



. *Front Leg Maximum Radius.*—With Lever 233½ tons compression; without Lever 235 tons compression. B. *Front Leg Minimum Radius.*—With Lever 156½ tons compression; without Lever 142 tons compression. C. *Back Leg Maximum Radius.*—With Lever 12 tons compression; without Lever 92½ tons tension. D. *Back Leg Minimum Radius.*—With Lever 24 tons compression; without Lever 23 tons compression.

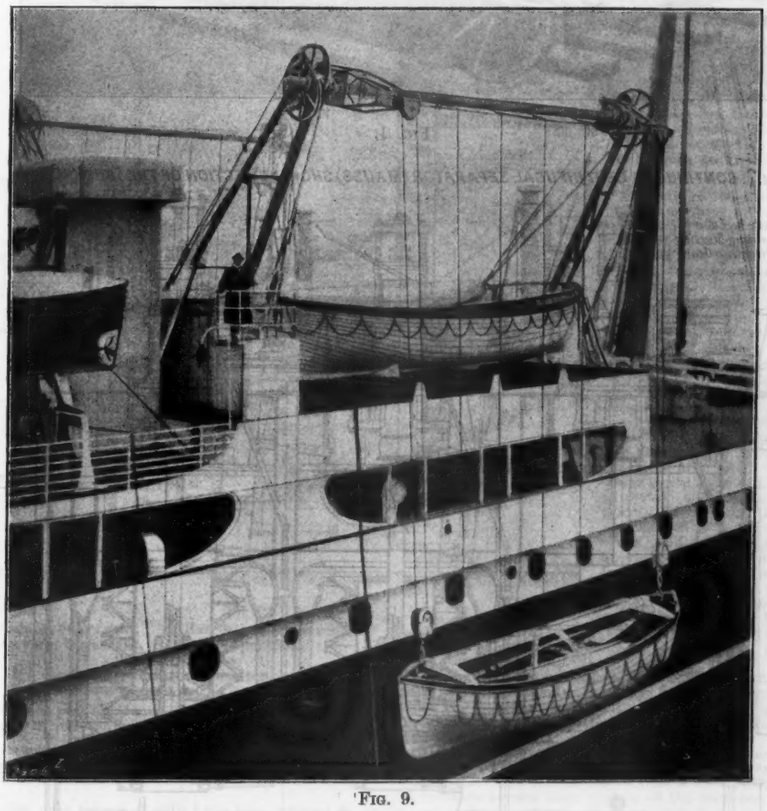


FIG. 9.

SUGAR MACHINERY.*

By the Right Hon. Lord INVERNAIRN, Member.

THE association between cane-sugar manufacturers and engineers has been long and of continuous growth. Its importance to-day may be gathered from the progress shown by the history of the sugar industry. Developments and improvements, due to engineering, have largely increased the quantity and quality of sugar which now can be extracted from sugar-cane.

PROGRESS OF SUGAR-MAKING.

Ancient up to Modern Times.—The date at which cane-sugar manufacture had its beginning is not authentically established; but India has, by general agreement, been credited with the first production of sugar, and the process used was probably to all intents the same as that employed for making "Gur"; except that, in ancient times, the juice was squeezed from the cane by means of a lever of wood inserted into a hole cut horizontally in a tree stump, the cane being placed between the lever and the lower side of the hole. From India the manufacture of sugar spread to China, Arabia, Egypt, and the Mediterranean coast, then into Spain. From Spain the sugar-cane was transported to various places; it reached Brazil in the beginning of the sixteenth century, Santo Domingo about 1520, Martinique about 1650, and the West Indies about 1700.

In early times the machinery in use was crude, and we may take it that by 1800 it would be on the whole like the Gur plant now in use. As time elapsed, the process of manufacture has been divided into stages. At first there were only two stages: namely, juice extraction and concentration with skimming. Now there are several stages, including the after treatment of scums, and these can be indicated most easily by naming the principal machines used, namely, mills, clarifiers or subsiders, mud subsiders, filter presses, evaporators, vacuum pans, crystallisers, centrifugals.

As only a rough survey of the progress of the industry is attempted, descriptions of plant and process are taken at intervals of twenty years, starting with 1800.

In the results shown, the terms used may be unfamiliar to some members, and have meanings as follows:—

"Crushing" is the weight of normal juice extracted, as percentage of the weight of cane.

"Extraction" is the sucrose in the juice extracted as percentage of the sucrose in the cane.

"Recovery" is the sucrose in sugar made, as percentage of sucrose in the juice extracted.

"Pol" or "Polarisation" is the percentage of sucrose in the sugar, as indicated by the polariscope.

"Net" is the estimated quantity of refined sugar which may be recovered in the refinery, from 100 of the raw sugar in question.

The "net" figure is given as it assists in arriving at

* Paper read before the Institution of Mechanical Engineers, at Glasgow, June, 1923.

a true conception of the progress in raw sugar manufacture.

1800.—Plant, comprising vertical three-roll mill and one boiling pan, yielded results approximating :—

Crushing, 62·5 per cent.
Recovery, 63·6 per cent.
Extraction, 71 per cent.
Pol., 70 per cent.
Net, 35·5 per cent.
10·8 tons cane or 6·75 tons juice per ton sugar.
30·4 tons cane per ton net. Molasses none.

The extraction may appear high, but it must be remembered that in the mills described, which were of small dimensions—6 in. to 8 in. diameter of roll—the canes would pass through only two or three at a time, and then were often doubled up and re-passed through the mill ; so that each cane received individual attention. The losses in manufacture were very great through spilling, inversion of sucrose and burning. While at that period it is likely more than one pan was used, the results shown may be taken as possible, and, in fact, survive now as given in Gur making ; in any case they serve as a starting point.

1820.—Plant, three-roll horizontal mill driven by cattle, wind-mill, waterwheel, or slaves. Two open-fire clarifiers and copper wall.

Lime was added to the juice in the clarifiers, and scum which floated as a result of heating was removed ; then the juice was baled or flowed from the clarifier to the first pan ; and, as it became concentrated, passed to the succeeding pans until it reached the desired consistency of thick syrup. From the last pan the syrup was baled into a gutter leading to shallow cooling boxes of wood or masonry, and allowed to cool, with occasional stirring, until crystallisation was complete. The mixture of sugar crystals and molasses—"massecuite"—was shovelled into hogsheads resting on beams over a large vat or sump. The hogsheads had a number of holes in their bottoms, closed by rods which reached to the top. After settling for a few days these rods were withdrawn, allowing the molasses to drain off ; the process being complete in two or three weeks.

The moist brown sugar remaining in the hogshead was called "muscovado," and was shipped to refineries in Europe.

Results :—

Crushing, 55 per cent. Extraction, 62·5 per cent.
Recovery, 54·8 per cent. Pol., 83 per cent.
Net, 66·5 per cent.
17 tons cane or 9·35 tons juice per ton sugar.
25 tons cane per ton net.

Molasses per ton commercial sugar about 0·33 tons, containing about 0·16 ton sucrose.

An ordinary factory of this description made about 1·5 tons muscovado per day of 10 hours, or 180 tons per crop of 120 days. Various improvements had already appeared before 1820, but were not yet in common use. The steam engine was first used in the cane-sugar factory about 1805. The vacuum pan was invented about 1813 and first used in Demerara in 1832. The steam clarifier was invented about 1816, and open steam finishing pans came into use about the same time.

1840.—The usual plant might consist of steam-driven mill, steam clarifiers, copper wall for evaporating to the syrup stage, and open steam finishing pans. The steam boiler would be set in line with the copper wall, and supplied steam to engine and finishing pans, while the clarifiers used the engine exhaust.

The principal improvement in results was due to the lower temperature used in the finishing pans where the maximum temperature of heating surface would be about 310 deg. F. against about 1,800 deg. F. with the copper wall ; the actual temperature of the boiling sugar being about 238 deg.

Results :—

Crushing, 55 per cent. Extraction, 62·5 per cent.
Recovery, 67·5 per cent. Pol., 85 per cent.
Net, 76 per cent.
14·5 tons cane or 8 tons juice per ton sugar.
19·2 tons cane per ton net.

Molasses per ton sugar about 0·31 ton, containing about 0·14 sucrose.

An ordinary factory of this kind made about 3·5 tons muscovado per day, or 420 tons per crop. The curing of the sugar was in hogsheads as before. The centrifugal machine was invented about 1837, and was first used in Java about 1853, and the multiple effect evaporator about 1846, but both came into use slowly.

1860.—The usual plant was much as in 1840, except that the finishing was done in a vacuum pan, the juice being evaporated to syrup in the copper wall, and the massecuite still drained in hogsheads.

The principal improvement was due to reduction of boiling temperature from 238 deg. to about 166 deg. F., and to the fact that the massecuite was boiled out of contact with air.

Results :—

Crushing, 55 per cent. Extraction, 62·5 per cent.
Recovery, 78 per cent. Pol., 88 per cent.
Net, 80 per cent.
12·6 tons cane or 6·93 tons juice per ton sugar.
15·75 tons cane per ton net.

Molasses per ton sugar about 0·22 ton containing about 0·11 ton sucrose.

A common size of factory made 4 tons muscovado per day, or 480 tons per crop. The filter press was invented about 1864, and the suspended centrifugal about 1852, improved 1867. The modern type of mill housing appeared in 1858.

The hydraulic pressure regulator for mills was invented and patented by Duncan Stewart, Glasgow, in 1870. The effect of this invention has been to secure flexibility and safety in the operation of milling plants. It has enabled the capacity and efficiency of factories to be increased to a degree which otherwise would have been impossible. Six-roll mills were in a few factories at this time ; and maceration, or the addition of water to the bagasse between the mills, was patented as early as 1840.

As the years went on and the plant became more elaborate, the working day was lengthened first to 22 hours, and then to 24 hours. This increase was necessary also to get any return on the increased capital involved and to compete against beet sugar.

1880.—Plant would include three-roll mill, steam clarifiers, filter presses for scums, triple effect evaporator, vacuum pan, wagons in which massecuite was cooled, pug-mill or breaker for cooled massecuite, tanks for cooling low massecuite at rest, centrifugals, and steam boilers. Generally first, second and third massecuite were made.

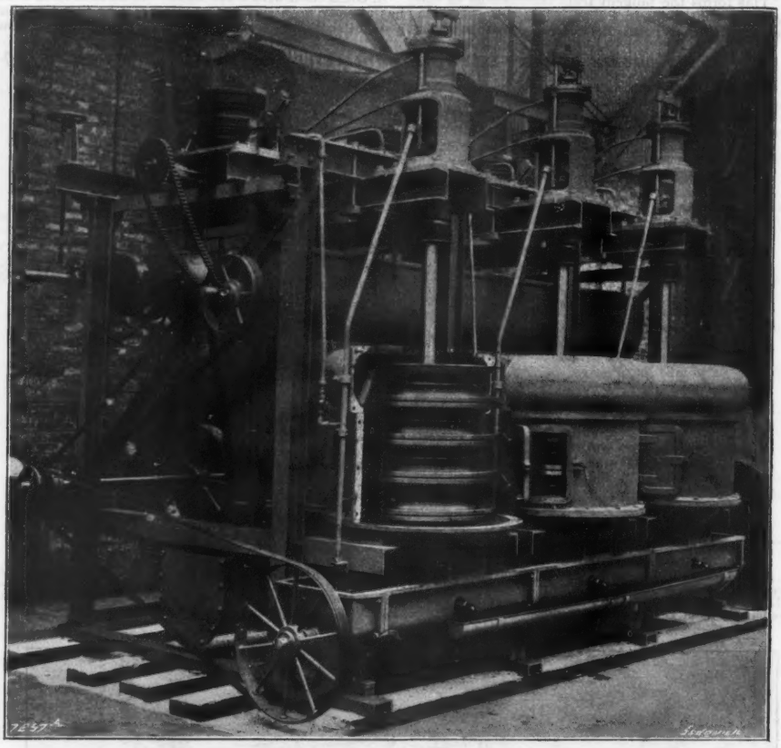
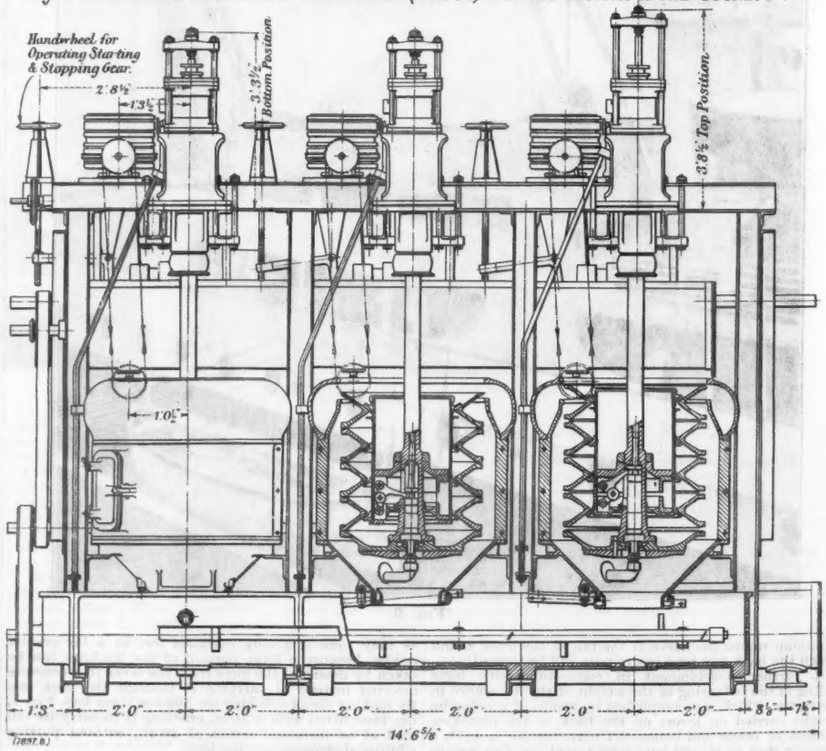


FIG. 1.

Fig. 2. CONTINUOUS CENTRIFUGAL SEPARATOR (MAUSS) SHOWING SECTION OF THE "BUCKET."



the first cured hot in the centrifugals, second boiled from first molasses, cooled in wagons, and broken in the pug-mill before curing. The third massecuite boiled from second molasses was allowed to cool in tanks for prolonged periods before reaching the centrifugals. Three qualities of sugar were thus made.

The principal improvements were greater extraction through improved mills, the saving of sugar recovered by the filter press, less inversion through the lower boiling temperature in the evaporator, and the sugar recovered by reboiling of molasses. The latter saving might be credited to the centrifugal, which at the same time enabled better sugar to be obtained. First sugar might now polarise 96 deg., second 90 deg., and third 83 deg., average, say, 94 deg.

Results :—

Crushing, 66 per cent. Extraction, 75 per cent.
Recovery, 76 per cent. Pol., 94 per cent.
Net, 90 per cent.
11·5 tons cane or 7·6 tons juice per ton sugar.
12·75 tons cane per ton net.

Molasses per ton sugar about 0·56 ton, containing about 0·21 ton sucrose.

A common size for such factory would make 20 tons sugar per 10 hours, and as the working day had been extended to 22 hours, the output would be 5,280 tons per crop.

So far, only three roll mills have been referred to, as they were most usual. Multiple crushing had been used from 1840 in a few places. A three-roll mill followed by a two-roll mill was used in 1848 with maceration; the addition of a second two-roll mill was patented in 1876, and the nine-roll mill appeared about 1892. In the early days multiple crushing was condemned as spoiling both juice and bagasse, and doubtless it did both at that time as the boiling-house plant, and methods then prevailing, would be unable to recover the extra sucrose extracted on account of the poor arrangement for crystallising and curing the sugar. The bagasse at the time had to be sun-dried; being spread and collected by hand, it would be very difficult to handle for fuel purposes after double crushing.

The Krajewski Crusher, having two rolls with their surfaces formed as double helical gears, was patented in 1886, and has retained its position as preliminary crusher for the cane. Shortly after 1890 the improvement in dryness of bagasse, through multiple crushing, made it possible to burn bagasse direct from the mills, with consequent saving in fuel.

1900.—The usual plant was similar to that of 1880, but with a nine-roll mill, which affected only the crushing or extraction. About 10 per cent. maceration water would be used on weight of cane, and bagasse would now contain about 47 per cent. fibre in place of about 35 per cent. as previously.

Results :—

Crushing, 81·01 per cent. Extraction, 92·04 per cent.
Recovery, 90 per cent. Pol., 96 per cent.
Net, 92 per cent.
8·10 tons cane or 6·56 tons juice per ton sugar.
8·80 tons cane per ton net.

Molasses per ton sugar about 0·293 ton, containing 0·093 ton sucrose. Factory output 100 tons sugar in 10 hours, and, as the working day is 24 hours, 28,800 tons sugar per crop.

Since 1910 the developments have been principally the lengthening of the mill train which may now consist of 22 rolls; and minor refinements throughout the whole factory, including the mixing of water with filter-press cake and refiltering the mixture to recover more sugar. In many places revolving knives at one or more points on the cane carrier, to cut and compact the cane before reaching the crusher, are installed; also shredders after the preliminary crushers. The shredder consists of revolving hammers mounted on a horizontal shaft and by their action the cane is beaten to matchwood; thus making a very uniform blanket of material for the mills, and enabling maceration to be applied at an early point of the mill train. Where shredders are employed it is usual to find that maceration water has at the same time been increased greatly and it is doubted whether the increased extraction is due to the shredder or to the extra water added. The bagasse obtained with shredder in use is generally drier than without the shredder.

1920.—An up-to-date factory would include the same machinery as in 1910, except that the mill would have 22 rolls, and the scums would be refiltered. Probably all the machinery in the sugar house would be driven by electric motors, in some cases the mills as well.

Results :—

Crushing, 83·6 per cent. Extraction, 94·99 per cent.
Recovery, 93·14 per cent. Pol., 96 per cent.
Net, 92 per cent.
7·59 tons cane or 6·34 tons juice per ton sugar.
8·25 tons cane per ton net.

Molasses per ton sugar 0·194, containing 0·058 ton sucrose. Factory output 165 tons sugar in 10 hours, or 47,520 tons per crop.

The results given are repeated in Table I, and indicate good practice; but they are not to be taken as the best for the various periods. The region covered may be taken as Jamaica for earlier dates, followed by Demerara and Brazil, with Cuba for the later periods.

Fig.3. **FLOW SHEET OF THE CLARIFICATION PROGRESS (MAUSS-STEWART).**
Arrows indicate Flow of Juice from Mills to Evaporator & Treatment of Scums.

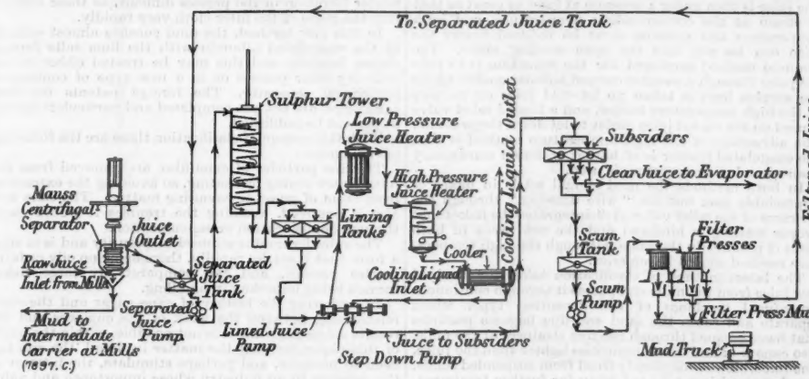
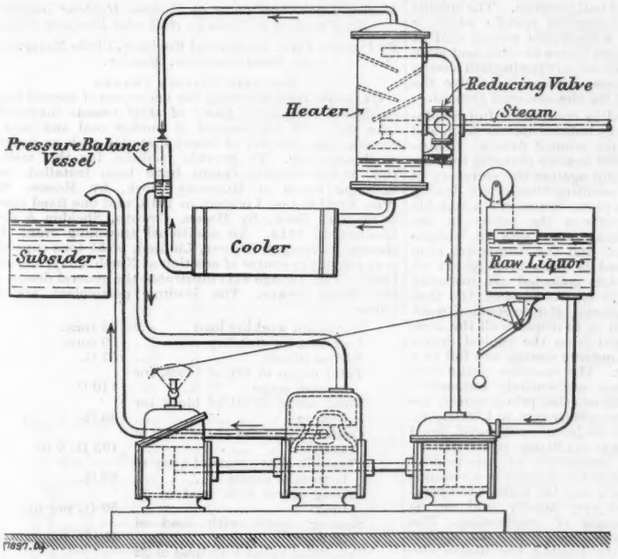


Fig.4. **DIAGRAM SHOWING HEATING AND COOLING OF JUICE, ALSO METHOD OF RELIEVING PRESSURE. (STEWART AND MAUSS.)**



Crushing, 75 per cent.
Recovery, 76 per cent.
Extraction, 85·22 per cent.
Pol., 94 per cent.
Net, 90 per cent.
10·14 tons cane or 7·6 tons juice per ton sugar.
11·09 tons cane per ton net.

Molasses per ton sugar about 0·56 ton, containing 0·21 ton sucrose. Factory output about 45 tons sugar in 10 hours, or 11,880 tons per crop.

Previous to the advent of multiple crushing, mill rollers had reached large dimensions; rolls 42 in. to 48 in. diameter, and 84 in. long were not uncommon, and for two-roll mills the diameter was even 60 in. with a length of 78 in. and hydraulic load of 800 tons. Experience with earlier multiple mills showed that, besides giving better extraction, more cane could be crushed than with three rolls of the same dimension. As a matter of fact the real advantage, after the first few rolls, is increased capacity, and with longer trains of mills the improved extraction obtained is due principally to the larger number of points where water or dilute juice may be applied. Thus as the size of factories increased, the mill train became longer, using rolls 32 in. to 36 in. diameter, and 66 in. to 84 in. long; the usual train being nine or twelve rolls generally, preceded by a pair of crushing rolls, or "an eleven-roll mill" or "a fourteen-roll mill."

About 1900 "crystallisation in motion," which had already been extensively used in the beet sugar industry, began to be used in cane factories. The crystalliser is a horizontal cylindrical or U-shaped vessel with stirring arms inside.

In the crystalliser the massecuite from the vacuum pans is left for various times before going to the centrifugals. First massecuites may remain a few hours, and low products several days, cooling all the time and kept in motion by the stirrers which revolve about once per minute. The effect is to increase the size of the sugar crystals by the deposition of sucrose from the surrounding molasses. At the same time "false grain," or minute extra crystals between those already formed, is prevented to a great extent. Thus more sugar of the better quality is recovered than previously, and it cures in the centrifugal more readily by not being clogged with false grain. A further benefit from crystallisation in motion is that it enables sugar to be recovered from molasses that previously would have been discarded as spent.

1910.—The plant would include fourteen-roll mill, juice heaters raising juice to near boiling-point, clarifiers or subsiders with small heating surface, filter presses, quadruple effect evaporator, vacuum pans, crystallisers, and centrifugals as principal items.

Results :—

Crushing, 81·01 per cent. Extraction, 92·04 per cent.
Recovery, 90 per cent. Pol., 96 per cent.
Net, 92 per cent.
8·10 tons cane or 6·56 tons juice per ton sugar.
8·80 tons cane per ton net.

Molasses per ton sugar about 0·293 ton, containing 0·093 ton sucrose. Factory output 100 tons sugar in 10 hours, and, as the working day is 24 hours, 28,800 tons sugar per crop.

Since 1910 the developments have been principally the lengthening of the mill train which may now consist of 22 rolls; and minor refinements throughout the whole factory, including the mixing of water with filter-press cake and refiltering the mixture to recover more sugar. In many places revolving knives at one or more points on the cane carrier, to cut and compact the cane before reaching the crusher, are installed; also shredders after the preliminary crushers. The shredder consists of revolving hammers mounted on a horizontal shaft and by their action the cane is beaten to matchwood; thus making a very uniform blanket of material for the mills, and enabling maceration to be applied at an early point of the mill train. Where shredders are employed it is usual to find that maceration water has at the same time been increased greatly and it is doubted whether the increased extraction is due to the shredder or to the extra water added. The bagasse obtained with shredder in use is generally drier than without the shredder.

1920.—An up-to-date factory would include the same machinery as in 1910, except that the mill would have 22 rolls, and the scums would be refiltered. Probably all the machinery in the sugar house would be driven by electric motors, in some cases the mills as well.

Results :—

Crushing, 83·6 per cent. Extraction, 94·99 per cent.
Recovery, 93·14 per cent. Pol., 96 per cent.
Net, 92 per cent.
7·59 tons cane or 6·34 tons juice per ton sugar.
8·25 tons cane per ton net.

Molasses per ton sugar 0·194, containing 0·058 ton sucrose. Factory output 165 tons sugar in 10 hours, or 47,520 tons per crop.

The results given are repeated in Table I, and indicate good practice; but they are not to be taken as the best for the various periods. The region covered may be taken as Jamaica for earlier dates, followed by Demerara and Brazil, with Cuba for the later periods.

TABLE I.—*Technical Results.*

Period.	"Gur" or 1600.	1820.	1840.	1860.	1880.	1900.	1910.	1920.
Crushing, per cent.	62·5	55·0	55·0	55·0	66·0	75·0	81·01	83·6
Extraction, per cent.	71·0	62·5	62·5	62·5	75·0	85·22	92·04	94·99
Recovery, per cent.	63·6	54·8	67·5	78·0	76·0	76·0	90·0	93·14
Tons juice per ton commercial sugar ..	6·75	9·35	8·0	6·93	7·60	7·60	6·56	6·34
Tons cane per ton commercial	10·8	17·0	14·5	12·6	11·5	10·14	8·10	7·59
Tons cane per ton net	30·4	25·0	19·2	15·75	12·75	11·09	8·80	8·25
Sugar polarisation	70·0	83·0	85·0	88·0	94·0	94·0	96·0	96·0
Sugar net..	35·5	66·5	76·0	80·0	90·0	90·0	92·0	92·0
Molasses per ton commercial sugar ..	—	0·33	0·31	0·22	0·56	0·56	0·293	0·194
Molasses contains ton sucrose	—	0·16	0·14	0·11	0·21	0·21	0·093	0·058

Chemical Control.—In the early days of the industry, rule-of-thumb methods prevailed, and even as lately as 1880 most factories were content with the use of a hydrometer for observing the densities of the various liquids, and litmus paper, assisted by the eye, for testing to regulate the purification of the juice. A small number of factories owned polariscopes and apparatus for rough analysis of the products; but as few trained chemists were employed and these practically as mere observers, the industry did not benefit much from them. The first formal account of chemical control in cane-sugar factories was published 1881.

Java, after some years of misfortune, including competition from beet sugar, began to employ trained chemists extensively, and about 1886 a system of mutual control was instituted. The effect of this was to place Java among the greatest sugar-producing countries and to show the advantage of chemical control.

Other regions soon followed Java's example, and now most modern factories, of capacity to handle 1,000 tons or more of cane per day, employ chemists.

The chemist analyses all materials in process, and sends his results to the management for its guidance. In conjunction with the factory manager and the chief engineer, the chemist makes up daily, fortnightly and annual reports showing for the "run" and "to date" many details of the performance. Such details include: Days elapsed, days grinding, time lost, tons cane crushed, composition of cane, maceration water used, quantity of juice extracted and its composition, dilution caused by maceration, sucrose extracted and left in bagasse,

moisture in bagasse, sucrose recovered and left in molasses, filter-press cake and sucrose in same, extra fuel used besides bagasse, and many other items.

The special points watched are the amounts of sucrose in bagasse, press cake, and final mollasses as percentages of the sucrose in the cane; also the ratio of glucose to sucrose present from beginning to end of process, as any increase in this ratio shows that sucrose is being "inverted" or turned into glucose. The following figures will give some indication of the improvement since chemical control was adopted; such improvement being due to the combined efforts of manager, chemist and engineer.

The figures given in the table refer to a factory in Cuba during 1920. Hawaiian figures for the same year show considerable differences in detail, but the final result is only 1 per cent. different from the Cuban figures. It can be seen that the mill-work in Hawaii is much the better. This is accounted for by the fact that in Hawaii the cane (passed between rolls of the same size) is better prepared and relatively smaller in amount than in Cuba, and in addition a much larger percentage of maceration water is used.

On the other hand, much more sucrose remains in the Hawaiian molasses, and general losses are greater; this result, in 1920, being attributed to the effects of a strike during the year. Thus the yield of sugar from the same weight of cane is now about 56 per cent. more than in 1880. The benefit to the producer is obvious; as the

—	1880.	Cuba, 1920.	Hawaii, 1920.
Sucrose in cane ..	100·0	100·0	100·0
Sucrose in bagasse ..	25·2	5·1	2·55
Sucrose extracted ..	74·8	94·90	97·45
Sucrose in press cake	2·4	0·74	0·04
Sucrose in molasses ..	12·1	5·32	8·03
Sucrose lost	3·5	0·45	2·03
Sucrose in sugars ..	56·8	88·39	87·35

weight of machinery per ton sucrose in sugar made, is now only about 90 per cent. of 1880 weight, and the sugar made is of better quality. The rate per ton of machinery has, of course, advanced greatly since 1880, but so have all prices, including the price of sugar.

Improvements in Methods and Machinery.—The fact that, with even up-to-date machinery, over 10 per cent. of the sucrose in the cane is lost as sugar, shows the opportunity and scope for further improvements. The reduction in the loss in mill extraction to only 5 per cent. involves the use of about 18 per cent. maceration on weight of cane; but this added water in the juice calls for extra fuel to the extent of 10 per cent. to 15 per cent. expressed as bagasse. Still more extra fuel is required with 2·5 per cent. loss in mill extraction, as the dilution of juice is in that case about 30 per cent. So far, it has been assumed that the juice is uniform in quality irrespective of the number of mill rolls employed. In reality, the quality deteriorates with each additional crushing of the bagasse.

In the Hawaiian figures referred to, the purity of first mill juice was 87·24, last mill 68·2, and mixed juice 83·87. Thus the juice in 1880 required much less purification than the juice of to-day. A great improvement in the process of extraction of the juice from the cane would be attained if means were devised which would avoid the excessive grinding now employed. This may be indicated as one direction for study by the mechanical engineer.

The actual amount of impurities removed by clarification is very small, and in the Hawaiian case raised the purity of the syrup to 85·2. As the amount of inversion of sucrose in a modern factory is very small indeed, the final molasses may be considered as the concentrated glucose and impurities in the clarified juice, together with sucrose held in solution by the water of the molasses, or prevented from crystallising by the impurities. Such impurities consist of lime salts, of organic and mineral acids, and gummy matters originally in the juice, or formed by the hydration of cane fibre particles. These fibre particles are the direct consequence of the repeated crushing of the bagasse, and are so small that they escape through the finest screens used; persisting throughout all the stages of manufacture they appear in the molasses, and in the sugar, still recognisable as fibre particles, but altered somewhat through being partially dissolved away.

The elimination of these particles from the juice is perhaps the most serious problem at present before sugar manufacturers. The juice in Hawaii is more pure than that in Cuba, and the sugars made contain the same percentage of sucrose; but while the Cuban sugars are freely accepted by refiners, Hawaiian sugars are objected to partly on account of irregular sized crystals, and partly because of the trouble they cause in treatment after being dissolved. The cause of the difference may be taken practically that the cane crushing in Hawaii causes the juice to contain more fibre particles than does the less drastic treatment in Cuba.

Removal of the cane particles would contribute to reduce the quantity of molasses produced by less gummy matter being formed, and more sugar would crystallise. Screening of the juice has, so far, been insufficient to overcome this difficulty, and a remedy is wanted. This may perhaps be found through the application of knowledge developed in some other branch of industry.

Much has been done in the study and progress of means for separating the clarified juice or scums from the solid impurities; but the results still leave room for research by the mechanical engineer.

In the usual processes of juice clarification for the manufacture of raw sugar, after the juice has been passed through finely perforated strainers, it is heated to about 212 deg. F., and flows into tanks where a small proportion of lime cream is stirred in, sufficient to make it slightly alkaline to litmus. Thereafter the juice is allowed to settle, and the clear portion decanted to the evaporators. The remaining mud, amounting to 10 per cent. or 12 per cent. of the total, contains sand, particles of cane fibre coagulated albumin, cane wax, lime salts and other impurities, and is generally reheated and pumped into filter presses, to recover as much as possible of the valuable juice.

In some cases the mud is mixed with the dilute juice from the last mills, limed, heated and settled in conical tanks, so as to obtain a more concentrated mud amounting to 5 per cent. or 6 per cent. of the total juice, and this mud is returned on the bagasse intermediate carrier leading to one of the last mills, the object being to recover the contained juice and leave the solids in the bagasse.

In many factories a different procedure is employed, where the strained juice is limed cold, then pumped through heaters under pressure, so that its temperature is raised to 220 deg. to 250 deg. F. without ebullition. The juice is then under a pressure at least as great as that of steam at the corresponding temperature, and both temperature and pressure must be reduced before the juice can be put into the open settling tanks. The common method employed for the reduction is to pass the juice through a counter current tubular cooler, where the surplus heat is taken up by cold juice on its way to the high temperature heater, and a loaded relief valve is used on the cooled juice outlet to let down the pressure. The advantage of the high temperature method is that the coagulated matter is of harder or denser consistency than when low temperature is used.

In both methods the mud should settle in flakes of appreciable size, but the "wire drawing" through the aperture of the relief valve so disintegrates the flakes that proper settling is hindered and the net result in both cases is practically the same, although the high temperature method should be superior.

The latest method of clarification takes the strained raw juice from the mills and passes it through continuous centrifugal machines of the decanting type, which separate and catch the sand and fine bagasse particles that have escaped through the fine strainers at the mills, also cane wax and other impurities lighter than the juice. The juice, almost completely freed from suspended solids, overflows and is conducted away for further treatment.

Figs. 1 and 2, on page 818, show the arrangement of these machines, a section of the "bucket" being shown in Fig. 2.

The "Mauss" centrifugal separator consists of a series of conical drums which revolve horizontally on a vertical spindle running on two sets of ball bearings. The spindle is hollow, and contains an internal spindle which is attached at its top end to a hydraulic piston, and at the bottom end operates toggle levers to open and close the drum sections. This movement of opening and closing is controlled by a timing gear, adjustable to give the cycle of operations required for the material treated.

The machine is maintained in continuous full revolution. The liquor flows into the bottom conical drum and overflows upwards into all the conical drums. Centrifugal force moves the solids and heavier particles through the feed outwards, towards and against the periphery of the conical drums, leaving a resulting clear liquor flowing upwards and over the top lip of the drums into a suitable launder. The separation collects the solids to the quantity desired. The timing gear sets in motion the action of the toggle gear and the drums are then opened and closed. The feed is automatically cut off before opening, and the solids collected are instantly discharged by centrifugal force. At closing, the flow of feed is automatically turned on. Before opening, wash water may, if desired, be run in to displace all the clear liquor. The solids discharged from the conical drums are received in a stationary outside casing, and fall to a suitable gutter or conveyor. The machine works continuously, and all operations are entirely automatic. Drive is by belt from a motor or other prime mover, the speed of the separator being from 800 r.p.m. to 1,000 r.p.m.

After leaving the separator the juice is sulphured, limed and then heated under pressure to 220 deg. to 250 deg. F. the heating being finished preferably by injection of steam in a heater designed after the manner of a counter-current jet condenser. In this way the highest temperature of the juice is attained very rapidly, and can be kept constant, without danger of overheating. The steam is supplied through a reducing valve set to give the temperature desired. On leaving the heater the juice flows through a tubular cooler with a counter-current of cold juice to take up the surplus heat, so that the juice may leave the cooler at about 212 deg. F. The whole process is indicated on flow sheet, Fig. 3, page 819. The reduction of pressure is effected in the following manner, and as indicated on Fig. 4.

Assuming that a steam-driven duplex pump is used to pump the juice through the system, a float in the raw juice supply-tank is used to regulate the steam supply to the pump, so that the latter works in conformity to requirements. A pair of extra cylinders are added to the duplex pump, of about the same size as the pump cylinder, but are fitted with piston valves and valve gear so as to act along with the steam cylinders as driving cylinders. The working fluid for these cylinders is the cooled juice, at the same pressure as is maintained in the heater. In this manner the pressure on the juice is relieved without wire-drawing or increase in velocity, and the flakes of coagulated impurities are left intact.

As the raw juice pump must be large enough to overtake its work easily and to provide for its volumetric inefficiency, it follows that the extra motor cylinders which will always work at more than 100 per cent. volumetric efficiency, tend to remove more juice than enters the system. A balance vessel is provided with its highest point above the level of the juice in the heater, and its lowest part, communicating with the cooler outlet and pump, at a level somewhat lower than juice level in the heater. The difference between the juice levels provides head to cause the flow through the cooler, and the top of the heater is connected by a pipe with the top of the balance vessel. When the motor cylinders overdraw the juice the difference in juice levels becomes less, and the motor cylinders can then draw only air and gas liberated from the juice in the heater, or a little steam. A regulating valve is provided on the air-connecting pipe, and when it is desired to empty the system this valve is closed.

In ordinary clarification the mud consists of at least three portions: The sand and other heavy material which settles very rapidly; the coagulated albumin and part of the gums in combination with the added lime, which settle slowly; and the cane wax with minute quantities of other light material which remain floating. A small part of the impurities is of a fatty or waxlike nature and combines with part of the lime to form a soap or emulsion, and the effect of wax and this soap is to render filtration in the presses difficult, as these matters clog the pores of the filter cloth very rapidly.

In this new method, the mud consists almost entirely of the coagulated albumin with the lime salts formed during heating, and this may be treated either in the ordinary filter presses or in a new type of continuous centrifugal separator. The foreign patents for that centrifugal are not yet completed and particulars cannot at present be published.

With this system of clarification there are the following advantages:—

The fine particles of cane fibre are removed from the juice before liming or heating, so avoiding the extraction from them of gums or colouring matter. The cane wax also is removed, avoiding the troubles it would cause through emulsification or saponification.

The subsider mud is reduced in quantity and is in such a form that it settles rapidly, there being no oily or fatty matter present, and the comparatively large flakes formed being unbroken in handling.

In reviewing the history of cane sugar and the close relationship between the work of the engineer and the results achieved, while it is not possible, within the limits of this paper, to treat the matter in detail, the aim has been to promote, and perhaps stimulate, the interest of the engineer in an industry whose importance and value deserves his continued active co-operation.

MODERN DOCK APPLIANCES.

*Modern Dock Appliances at Glasgow Harbour including the Handling of Grain in Bulk also Dredging Plant.**

By DANIEL FIFE, Mechanical Engineer, Clyde Navigation Trust, Glasgow, *Member*.

ELECTRIC COALING CRANES.

GLASGOW Harbour being the home port of several large steamship companies, many of their vessels invariably take their full complement of bunker coal and load a considerable quantity of heavy material, such as boilers, machinery, &c. To provide facilities for this traffic, two 32-ton electric cranes have been installed, one travelling crane at Rothesay Dock, by Messrs. Sir Wm. Arrol & Co., Limited, in 1913, and one fixed crane at Queen's Dock, by Messrs. Cowans, Sheldon & Co., Limited, in 1914. An additional travelling crane, by Messrs. Babcock & Wilcox, Limited, of 35 tons capacity is at present in course of erection at North Quay, Queen's Dock. Fig. 1 (page 821) illustrates the general design of the 35-ton crane. The leading particulars are as follows:—

Maximum working load ...	35 tons.
Test load for stability	60 tons.
Radius (fixed)	57 ft.
Total range of lift of block for general cargo	110 ft.
Total range of lift of block for coaling	80 ft.
Centre of jib head above cope of quay	103 ft. 6 in.
Clear lift above cope of quay to bottom of cradle	65 ft.
Lifting speed with load of 32 tons	50 ft. per min.
Slewing speed with load of 32 tons	450 ft. per minute.
Travelling speed with load of 32 tons	60 ft. per minute.
The factors of safety are:—	
Structure and gearing ...	7½ to 1.
Hoisting and tipping ropes ...	8 to 1.
Weight of crane complete with 66 tons of back ballast ...	315 tons.

The gantry carrying the crane is of the portal type with a clear vertical height of 15 ft. and 30 ft. span between the rails. It is supported on 16 cast-steel wheels, 2 ft. 6 in. diam. on tread, which are mounted on compensating bogies to ensure the weight being equally distributed on the wheels. The top part of the gantry is provided with deep beams and transverse girders for the support of the roller path and centre pin. The lower roller path is a ring of cast steel 27 ft. mean diameter by 12 in. broad on which the revolving structure is supported by 64 live rollers, each 14 in. maximum diameter. The rollers are carried by a spider ring connected to a centre casting, and gun-metal washer plates are fitted for taking up the end pressure on the outer ring; each roller is provided with a separate lubricator.

The centre casting on the top of the gantry is of cast

* Paper read before the Institution of Mechanica Engineers at Glasgow, June, 1923.

steel, and is carried up to form the centre bearing for the revolving structure, which relieves the centre pin from side stresses and enables the pin to be easily withdrawn for examination. The top roller path is a continuous ring of the same material and section as the lower path; this construction has been found necessary in fast working coaling cranes.

The revolving frame carrying the gearing and motors is of very substantial design and formed of steel longitudinal cross-girders with a frame of rolled steel sections bolted thereto, on which the gearing and motors are fixed. The framing of the upper structure and jib is of rolled-steel sections throughout, well braced and connected by large gusset plates. The rope pulleys at the jib head are of cast steel, each revolving on a separate pin, and a four-plunger oil pump operated by an eccentric on one of the hoisting pulleys provides lubrication for all pulleys. Access by ladders is provided to all parts of the crane, and a platform with hand-rails is fitted at the jib head to facilitate examination and repairs. The hoisting purchase consists of four parts of plough steel wire, 4·3 in. in circumference, two parts of which are wound on to a cast-iron drum which is operated through two reductions of machine-cut double helical cast-steel gearing, by a motor of 180 b.h.p. Post brakes with internal free-wheel arrangement are provided to hold the load while at rest, and dash pots are fitted to prevent the brakes being applied in such a manner as would subject the gearing to shocks.

Fig. 1. 35-TON ELECTRIC COALING JIB-CRANE. GENERAL ARRANGEMENT.

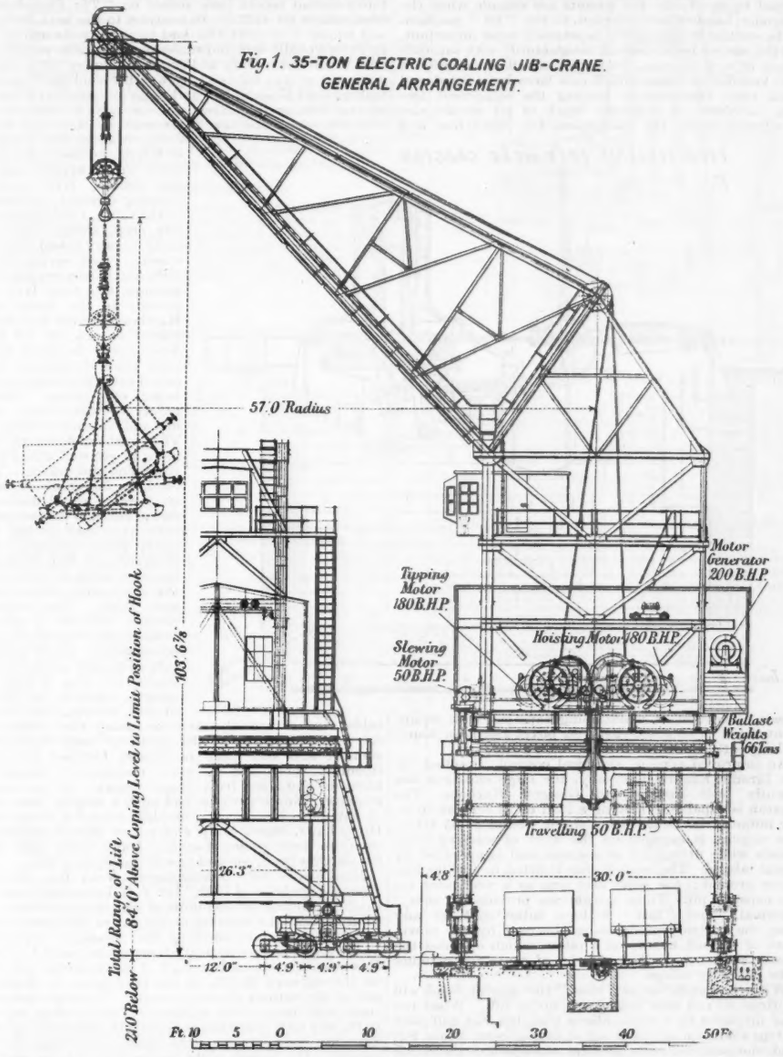
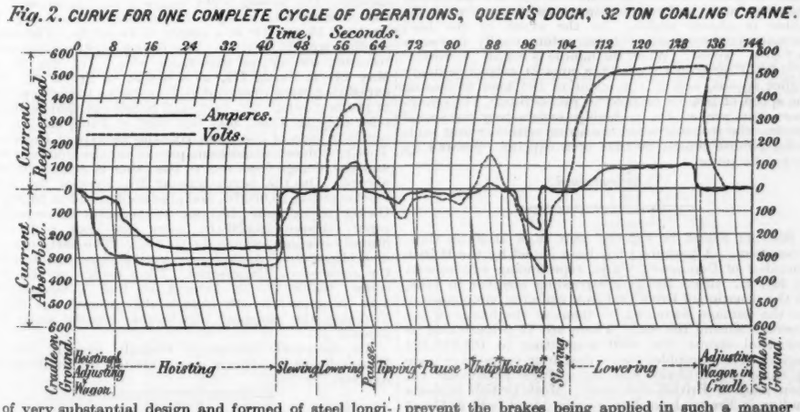


Fig. 2. CURVE FOR ONE COMPLETE CYCLE OF OPERATIONS, QUEEN'S DOCK, 32 TON COALING CRANE.



The crane is revolved by a 50 b.h.p. compound-wound motor through a phosphor bronze worm-wheel and cast-steel spur gearing. The pinion on the vertical shaft is supported by a steel casting, and engaged with a cast-steel rack bolted to the bottom roller path. A hand travelling crane is provided over the machinery, which is capable of lifting any of the parts for examination or repair.

Coaling Cradle.—The cradle is of the "Armstrong" through type capable of dealing with wagon 20 tons capacity of coal, and can be easily disconnected when the crane requires to deal with material other than coal.

Electrical Equipment.—The electrical energy is taken from the Glasgow Corporation mains, a switch-house being provided for the supply of continuous current at 500 volts to all the electrical appliances on the quay. Cables are laid from the switch house to a trench which extends the full length of the crane travel, and is fitted with bare conductors from which the current is collected by double-arm swivelling trolleys. Supply cables are carried through a centre pin to a switchboard in the control cabin.

The switchboard is provided with circuit breakers and switches to control the circuits to the motor generator, slewing and travelling motors and crane lighting. This cabin also contains a potentiometer regulator for hoisting and tipping motors, controllers for slewing and travelling motors and indicators showing height of lift and tipping angle of wagon. The electrical method adopted to operate and control the hoisting and tipping motors is the "Crompton" system, a modified form of the "Ward-Leonard" control. This provides a safe, accurate and efficient means of controlling the operations of the crane, for the handling of coal wagons and machinery; it also obviates the use of brakes when lowering light or heavy loads.

To supply direct current at variable voltage to the hoisting and tipping motors, a motor generator of 200 b.h.p. is provided in the machinery house, and consists of two direct-current machines which run at a speed of 680 r.p.m. rigidly coupled together and bolted to a cast-iron bed plate. The motor is of the standard type of shunt wound machine, provided with interpoles and designed to withstand rapid fluctuations of load without sparking. The generator is of the variable voltage type with separate excited fields. As this machine runs at constant speed, its voltage is always in direct proportion to the field strength, and the whole of the speed control in both directions of rotation of the hoisting and tipping motors is accomplished by varying from maximum to minimum and reversing the shunt current in the generator fields.

A reversing type potentiometer regulator, operated by the driver, controls the shunt current. The regulator is provided with a large number of contacts, which makes the control very sensitive and varies the volts from zero to plus or minus according to the position of the control lever when hoisting or lowering. In addition to the shunt winding on the field coils of the generator, a special limit series winding is embodied. This series winding carries the main current generated and is wound in the reverse direction to the shunt, thus opposing it and tending to weaken its magneto-motive force, the total magnetic flux being the resultant of the two windings. This arrangement of differential field winding has valuable safe-guarding features, preventing the operator exceeding a pre-determined speed of hoisting or otherwise overloading the apparatus. It is possible to throw the control lever into the full speed position of hoisting, lowering or tipping without causing excessive current to flow through the motor, as the limit winding by preventing too rapid a rise of the generator voltage does not allow the motor to be accelerated too quickly. The motor is so wound that its speed is proportional to the generator voltage applied across its armature terminals.

The hoisting and tipping motors are duplicates and each is of 180 b.h.p. at a maximum speed of 400 r.p.m. The armatures of these machines have no special features, but the field is compound wound which is more economical in field watts than a pure shunt winding would be when the motor is standing. The shunt winding is connected across the incoming 500-volt supply, and is excited from special contacts on the starter from the motor generator. The shunt current on the motors thus remains constant throughout the whole period the motor generator is running. The series field winding consist of a few turns of heavy conductor. Its magneto-motive force is thus proportional to the input current to the motor generator, and therefore proportional to the load on the hoisting or tipping motors.

These series turns increase the torque of the motor in proportion to the load being lifted, and being connected to the incoming supply, the necessity is obviated of reversing the series winding when current to the armature is reversed. As the shunt-field remains constant, the speed of the hoisting or tipping motors is practically dependent on the voltage across the armature. If there were no series field turns, the speed would be directly proportional to the applied voltage, but these windings tend slightly to decrease the speed of the motor when the load is at a maximum. The torque exerted by the motor is proportional to its field strength multiplied by the armature current, and sufficient forward current can be applied to the armature to exert the requisite torque for sustaining the full load.

Shunt wound solenoid brakes with dash-pots are provided on the hoisting and tipping gears, which are operated by a change-over switch, and so arranged that the brakes are applied when the current to the motors is insufficient to sustain the load, or released when the motor current has reached a value capable of lifting the load. The wear of the brakes is thereby reduced to a

minimum, which is demonstrated by the fact that in a similarly equipped crane after loading two and a-half million tons of coal over a period of seven years, the original brake linings are still in use.

During lowering, the necessary braking action is accomplished by regeneration, the generated voltage being reduced by the operator through the potentiometer to a value below the volts generated by the hoisting motor which runs as a generator, being driven by the descending load. Under these conditions current passes from the hoisting motor back through the motor generator set to the supply mains. The system gives smooth and effective retardation of the load and creeping speeds can be obtained when hoisting or lowering, and it is almost impossible to cause damage to the electrical portion of the gear by faulty handling of the controller, as no special skill is required by the operator. Fig. 2 shows the amperes and voltage taken during ordinary coaling operations by a similar crane, and represents a complete cycle of hoisting, slewing, tipping and lowering a truck loaded with coal, the time taken to complete the cycle being 2·4 minutes. The gross load including cradle amounts to 24 tons. This diagram shows the current taken in hoisting and tipping, also the energy returned to the line by the descending load and from which the calculated energy taken is found to be 147 e.h.p and the energy returned is 83 e.h.p.

The power generated by the descending load cannot all be taken as useful, as the loss in efficiency of the motors and motor generator requires to be made up before any current can be returned to the corporation mains. From meter reading over a number of years in actual working, the energy credited by the electricity department amounts to 8 per cent. of the total current taken.

Table 1 gives the efficiency of one of the electric coaling cranes taken under test conditions.

TABLE 1.—*Efficiency Tests.*

Weight in Tons.	Height in Feet.	Time in Secs.	Power. Volts.	Power. Amps.	Horse-Power. Loads.	Horse-Power. Electric.	Efficiency = L.H.P. / E.H.P.
							per cent.
32·0	50	40	490	365	162·9	239·74	67·5
24·0	50	37	495	280	132·0	185·8	71·0
17·15	50	35	500	220	99·8	147·4	67·7

Table 2 gives several examples of the performance of this crane in loading coal into bunkers, the average lift being about 30 ft.

TABLE 2.

Steamer.	Cargo, Tons.	Hours.	Tons per Hour.
Poplar Branch	1,489	6	248
City of Poona	5,290	31¼	169
King Edward	7,040	45½	155
Middlesex	3,510	21¼	165
Clan McGilvray	2,112	11¼	188
Shahristan	1,544	8¾	177
Jason	2,050	11½	181
City of London	2,973	17	175

Table 3 gives details of the working costs of shipping 464,255 tons of coal, almost exclusively into ships' bunkers, taken over the year 1922.

TABLE 3.

	d.
Wages of men on crane	0·23
Wages of cradle men	0·52
Electrical energy (88,985 units at 1·13d. per unit)	0·22
Maintenance, inclusive of wire ropes and stores	0·26
Pence per ton... ...	1·23

$\frac{\text{Tons } 464{,}255}{\text{Units } 88{,}985} = 5{\cdot}21$ tons per unit, or 0·19 unit per ton.

Interest, depreciation and general management charges are not included.

ELECTRIC CAPSTANS.

Experience gained over the past eighteen years has shown the Clyde free head capstan, 107 of which have now been installed at Glasgow Harbour, to be most efficient in service and very moderate in maintenance and repairs, especially as regards renewal of ropes. Fig. 3 illustrates an 18 b.h.p. capstan of this type employed in hauling loaded wagons on to a coaling cradle, which during the past six years has handled 2,500,000 tons of coal, only slight adjustments being required during that period.

A comparative cost of ropes, taken over a period, for one free and one fixed head capstan is as follows:—

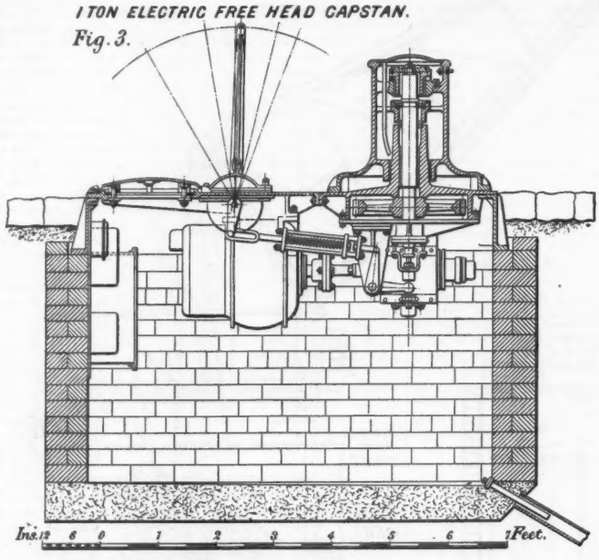
TABLE 4.

Type of Capstan.	Particulars of Ropes.	Length of Rope.	No. of Ropes per annum.	Total Cost of Ropes per annum.
		Ft.		£ s. d.
Free head	Plough steel wire, 2 in. circumference, 6 strands, 19 wires, breaking stress 13 tons	150	7	28 0 0
Fixed head	Manilla, 2½ in. in circumference	120	60	48 0 0

The electrical equipment of quay capstans requires special consideration, the motors found most saisfactory being of the drip proof type, with ventilating ducts on end shields, and of robust construction throughout. For the purpose of limiting the load which can be hauled by the capstans, fuses have been found to be unsuitable and self-setting single-pole circuit breakers have been fitted. These are interlocked with the controllers and tripped by overloads, the circuits are remade when the controller handles are returned to the "off" position.

The ventilation of electric capstans is most important, and this cannot be carried out satisfactorily with capstans placed in a 6 ft. way, but when installed alongside a wall, ventilating pipes with hoods have been fitted and found most beneficial in keeping the equipment free from moisture. A sufficient depth of pit should also be allowed below the mechanism for ventilation and access. The cost of maintaining capstans with equipment fitted in confined cast-iron boxes has been found to be greatly in excess of those with a deep pit.

1 TON ELECTRIC FREE HEAD CAPSTAN.
Fig. 3.



An improved type of electrical control, supplied by the Igranic Electric Company, for large capstans has recently been installed at Glasgow Harbour. The capstan is capable of hauling a load of 15 tons at 20 ft. per minute, the motor being shunt wound of 35 b.h.p. The capstan is engaged on the work of warping large vessels while fitting out at a crane, and is operated by casual labour. The control gear is fitted in a pillar box above ground; the pillar also acts as a ventilator for the capstan pit. Three speeds are provided, "slow," "normal," and "fast" without interchange of any gear, the various speeds being obtained by the movement of a small handle on a pillar, which operates the master switch controlling a series of contactor switches with jamming relays.

With the handle set at "slow," the capstan head will continue to run slow with loads up to full. When the load increases to a value above this, but not sufficient to trip the main overload set at 50 per cent. above full load, the jamming relay operates, the speed of the motor decreases and the head continues to revolve until the motor is almost stalled. In the event of the load decreasing, the speed of head automatically increases to "slow" speed. When the handle is set at "normal" or "fast" positions the motor runs at correspondingly higher speeds, and in the event of the load increasing the speed of head is reduced in proportion. The equipment has proved to be highly satisfactory in actual service, the features when operating with varying loads being almost similar to that of a capstan operated by hydraulic power.

(To be continued.)

BRITISH FIRMS IN FRANCE AND WAR DAMAGE COMPENSATION.—A pamphlet has been issued by the British Chamber of Commerce, Paris, reproducing two reports by Mr. H. Alfred Bell, corresponding member in Lille, on the situation of British subjects claiming compensation for the damage sustained by them at the hands of the Germans during the war. There are 71 private and 28 industrial claims, the total amounting to 168,825,195 francs. The pamphlet states that four years have gone by since the armistice and not a single penny has yet been paid to British claimants. Most British subjects trading in France have been paying taxes both in Great Britain and France, and they are helped by neither country. They hope that justice will now be meted out to them. It should not be forgotten, the pamphlet adds, that British subjects residing in France are mostly there to promote British trade and to import British goods into France. They are a necessity to British commerce and they look to the British Government to at last recognise that compensation is due to these British subjects for the damage sustained whilst endeavouring to increase British trade abroad.

ROYAL METEOROLOGICAL SOCIETY.

THE last monthly meeting of this society for the present session was held on Wednesday, the 20th inst., at 49, Cromwell-road, South Kensington, Dr. C. Chree, F.R.S., President, in the chair.

Messrs. J. E. Clark and I. D. Margary presented the thirty-second report (new series) on "*The Phenological Observations for* 1922." In contrast to the heat drought and sunshine of 1921 this had to discuss the effects of an exceptionally cool and sunless summer after mid-June, with much wet in July and August. Before this a fairly mild winter was followed by another cold early spring making fruit blossom late and so giving good expectation of excellent crops. Heat and sunshine of exceptional intensity signalised the latter part of May and early June, resulting in a rapidity of flower and insect development rarely experienced in our island. With accompanying draught, especially in the south, this injured the hay crop, spring oats and early potatoes, and, to less extent, other spring sown farm and garden crops. The ripening was very late, especially in the north and Highlands, much hay being ruined or not cut till late September. In north Scotland the oat harvest only ended with November, much being cut green. Fortunately October was very dry and November fairly so. This enabled southern farmers to get well ahead with ploughing and sowing. The isophene flower chart, with its lines of equal flowering dates, can now be compared with the lines giving the thirty years' average. The divergence on the average is not very large, so great was the acceleration due to May and June. The migrant records indicate a similar sudden speeding up of their movements. As it is difficult with field crops to find stages at this period of growth capable of giving precise records, both these tables are of special value for doing this indirectly. As a consequence of the previous very favourable summer and still more favourable October for wood ripening, there was a most remarkable display of blossom and fair fruit crops despite the untoward summer. Never perhaps had such a display been seen of hawthorn bloom, even on close-trimmed hedge-rows. Hips, haws, hazel, holly and privet berries abounded, even on very young bushes. Many trees bore fruit for the first time, some of species rarely seen here.

In a paper on "*Meteorological Notes from the Mt. Everest Expedition of* 1922," Dr. T. G. Longstaff explained that the difficulties encountered on the expedition were so great that the energies of the entire party were completely occupied in climbing the mountain and consequently few meteorological observations could be made. However, a systematic record of temperature was kept on the outward March, at the base camp at 16,500 ft. and at the various climbing camps. The night temperatures were taken with minimum thermometers exposed to the sky on wooden boxes about 1 ft. above the ground. The day temperatures were taken with sling thermometers. The lowest night temperature experienced on the outward march, April 12 to May 1, was 8 deg. F., on April 13 and 19, at a height of 14,000 ft. The mean reading was 15 deg. F. The lowest night temperature recorded during the expedition was — 12 deg. F. on May 27, at Camp III, at a height of 21,000 ft. The expedition came to an end in June owing to the approach of the monsoon. Dr. Longstaff points out that his notes refer only to April, May and part of June, and on the northern side of the main Himalayan axis of elevation. Totally different conditions prevail on the southern side and the change from one to the other is extraordinarily abrupt. On the north side of Mt. Everest the snow level is put at 20,000 ft., and glaciers descend to 16,500 ft. Owing to extreme dryness, evaporation is incredibly rapid. Above 25,000 ft. snow does not melt, but literally evaporates into the thin air. The party camped in a blizzard at 15,000 ft. on April 8, but next morning the snow soon disappeared. They awoke at the base camp, 16,500 ft. on June 4 to find a covering of 4 in. of snow; by 10 o'clock the ground was dusty. Probably the constant high winds greatly assist this phase.

An open-scale barograph recently brought out by Messrs. Short and Mason was exhibited by Mr. Rowland Arnison.

TEXTILE TECHNICAL SCHOOL IN CHINA.—Some time ago the proposal was made by the Textile Machinery Makers' Association that part of the Boxer Indemnity should be devoted to the foundation of a textile technical school in China. The suggestion has been well received, we understand, in China, and a recent meeting of millowners, representing 1,500,000 spindles and 8,500 looms, gave approval to the scheme. We are informed that support is expected to take a more definite form when the present depression has given place to better things.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

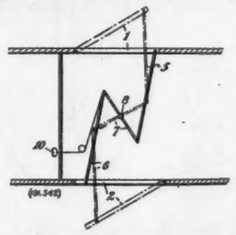
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

191,542. V. Sevian, Kilburn. Aeroplanes. (3 *Figs.*) November 15, 1921.—The improvements have for their object the provision of means which, when a nose-dive occurs, can be brought into action to cause the aeroplane to resume its normal flying position. Apparatus for the purpose mentioned comprises a pair of auxiliary planes 1, 2, disposed parallel to one

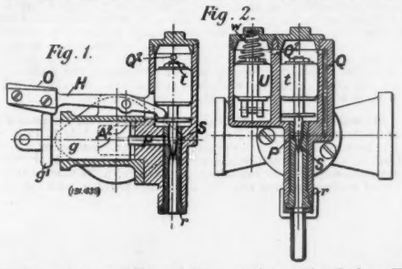


another, the one, 1, above and the other, 2, below and transversely to the longitudinal axis of the aeroplane, mounted on pivots along their rear and forward edges respectively. The planes are connected together by rods 5, 6, 7, the rod 7 being pivoted at the point 8. The rods and planes are operated by a handle 10. (*Accepted January 24, 1923.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

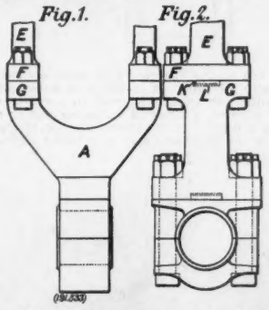
191,439. W. F. Grafton, Ibroxholm, Glasgow. Carburettors. (6 *Figs.*) October 7, 1921.—Air to be carburetted is admitted past a rectangular choke A^2 by withdrawal of a member *g* as shown in Fig. 1. Fuel is admitted to a nozzle P, past a needle valve S, which is raised by engine suction action on a piston *t* through a passage Q. The lift of the needle valve S is limited by a lever H having an adjustable plate O which makes contact with a projection g^1 on the member *g*. The suction also acts through a hole Q^2 on a piston U which,

Fig. 2.



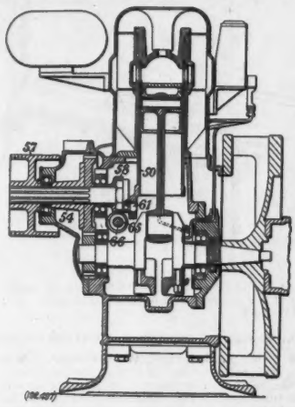
moving against a spring *w*, rotates a spindle on which the lever H is eccentrically mounted. By this means the fuel supply is reduced automatically when the speed of the engine increases. The fuel supply may also be controlled by a hand-actuated cock in tube *r*. A recess is made in the end of the member *g* to accommodate the end of the nozzle P, and whistling is prevented by providing the recess with a loose piston which is drawn forward by the suction to close its mouth. The pistons U and *t* are preferably made of graphite. (*Sealed.*)

191,533. North British Diesel Engine Works (1922), Limited, Whiteinch, Glasgow, and J. C. MacC. Maclagan, Drumchapel. Connecting Rods. (2 *Figs.*) November 10, 1921.—The invention relates to forked connecting rods for reciprocating engines. A forked connecting rod made according to the invention comprises essentially two side rods E made



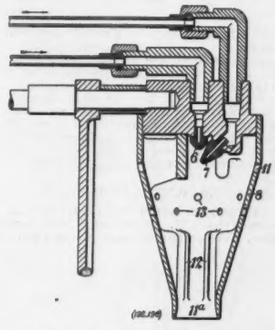
separate from the forked end piece A. The adjacent ends of the side rods and the forked piece are flanged at F, G respectively, and are rigidly attached to one another by means of bolts and nuts. The accurate alignment of the bolt holes is ensured by a spigot K formed on the flange F engaging a socket L formed in the flange G. (*Sealed.*)

192,497. W. Guthrie, Motherwell, and Wallace (Glasgow), Limited, Dennistoun, Glasgow. Internal-Combustion Engines. (2 *Figs.*) November 4, 1921.—In an internal-combustion engine wherein the admission of the combustible charges and the exhaust of the burnt gases is controlled by a single sleeve valve and in which a half-speed shaft, supported in a bearing in the crank-case and in a bearing in a crank-case cover, drives the sleeve valve with a combined reciprocatory and angular



motion, the half-speed shaft 54 is, in accordance with the invention extended through the crank case cover and provided with a driving pulley 57. The half-speed shaft may be provided with a spherical member 61, which engages with a bearing formed in the sleeve valve 50 for the purpose of operating the latter. A helical gear 58 may also be secured at the inner end of the half-speed shaft and arranged to drive a helical gear 65 fixed to a transverse shaft 66, which drives a magneto and a governor. (*Sealed.*)

192,196. W. T. Bell, Lincoln, and A. S. Castle, Lincoln. Internal-Combustion Engines. (2 *Figs.*) November 7, 1921.—The invention relates to a hydrocarbon burner which is specially useful for burning refined or crude oil and for heating the hot caps of semi-Diesel oil engines at starting, but is also useful for burning ordinary oil for heating an external tube or part of a combustion chamber of other oil engines. According to the invention, the air nipple 6 is central with the tube 8, and the



air jet is struck by oil issuing from the nipple 7, which is at an angle to the air jet. The oil is thoroughly atomised and the pressure of the atomised liquid sucks in atmospheric air through the holes 11, 13, which assists in further atomising the oil and forming a perfect mixture which is further divided up by the webs 12 in the nozzle 11*a*, so that the mixture when it reaches the end of the nozzle 11*a* is in perfect condition to be lighted and an efficient flame produced. (*Sealed.*)

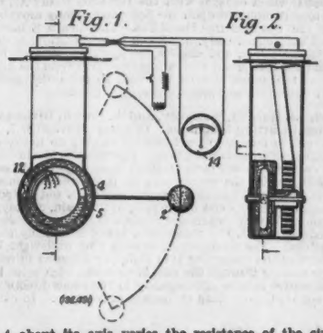
HYDRAULIC MACHINERY

191,444. A. B. Osborne, Birmingham, and Sodazone Limited, Birmingham. Valves or Taps. (2 *Figs.*) October 8, 1921.—According to the invention, in a tap or valve of the kind having a reciprocating outlet valve member of conical form which is adapted to make contact with a conical seating formed in a detachable discharge nozzle, the valve member 4 consists of a cone of rubber or other compressible material which is adapted

to make contact with the seating 2 on the discharge nozzle 3 to close the valve. Further, the valve spindle 5 extends into a removable cap portion 7 on the casing 8, where it is engaged by the inner end of a lever 12 passing through and pivoted on the cap 7 and projecting beyond its pivot to form an operating handle, a fixed handle 10 being also provided on the cap 7. (*Sealed.*)

192,491. C. Hyland, Hunslet, Leeds. Indicating and/or Recording Fluid Levels. (5 *Figs.*) November 3, 1921.—The invention relates to instruments for indicating and also, if necessary, recording, the level of a fluid in a vessel, and comprises a float 2 and a closed annular U-shaped or other hollow body 4, partially filled with mercury 5, disposed in two limbs thereof, and adapted to undergo rotary movement about its horizontal axis as the float 2 rises or falls. A metal wire 12 is fixed within the body 4 and forms part of an electric circuit containing a galvanometer 14 or the like indicating and/or recording device. The parts are so arranged that rotation of the

Fig. 1. *Fig. 2.*



body 4 about its axis varies the resistance of the circuit by varying the length of the wire 12 immersed in the mercury. (*Accepted February 14, 1923.*)

LIFTING AND HAULING APPLIANCES.

192,243. Cowans, Sheldon and Co., Limited, Carlisle, and J. B. Pearson, Carlisle. Lorry Cranes. (3 *Figs.*) December 5, 1921.—The invention relates to self-propelled road vehicles carrying a crane and comprising a jib arranged for slewing movements. According to the invention, an arm or shoe *f* is connected by a pivot to the vehicle chassis above one or more of the wheels *a* of either the rear or front pair, or both wheels, the arm or shoe *f* being normally raised clear of the wheel, but adapted to be lowered about its pivot *g* to its working position in which it projects over the wheel so as to bear thereon upon lateral tilting movement of the vehicle taking place. Means are

Fig. 1.

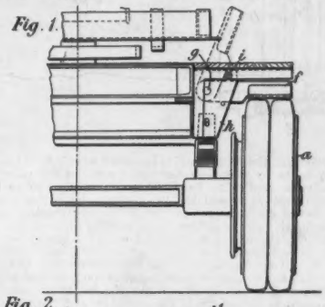
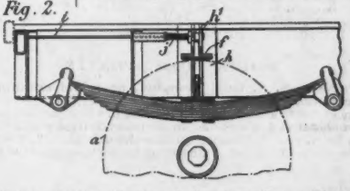


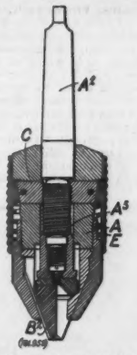
Fig. 2.



provided for holding the shoe in its alternative positions and comprises advantageously a manually operable spring-bolt *i* to engage above or below the shoe *f* to hold it in raised or lowered position at will, a preferred arrangement consisting in providing the bracket A with spaced cheeks A^1, which embrace the shoe and have co-axial bores through which the bolt head engages to hold the shoe in the alternative positions. The bolt *i* is under the influence of a spring *j* tending to hold it in working position, *i.e.*, so that it bridges the cheeks A^1, and to allow the shoe to be raised or lowered the bolt is withdrawn by means of the handle. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

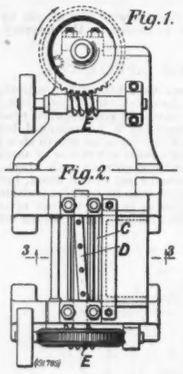
191,959. Sir A. Herbert, Dunley Manor, near Whitchurch, and A. H. Lloyd, Earlsdon, Coventry. Chucks. (4 *Figs.*) January 13, 1922.—The invention relates to drill chucks for parallel-shanked drills of the kind in which there is a

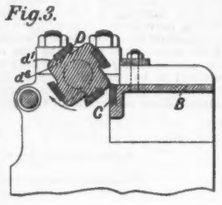


threaded connection between the chuck body and the driving shank to effect the gripping and the release of the drill. According to the invention, a divided nut C is employed to connect the shank A^2 with the chuck body A, and can be engaged or disengaged during the rotation of the chuck by means of a sleeve E

loosely mounted upon the body A. Preferably the chuck comprises an externally screw-threaded driving shank A^5, a tool-carrying body A loosely mounted thereon, provided with a divided nut C which engages with the threaded shank A^5, and a sleeve E loosely mounted upon the body and axially movable to disengage the nut and free the drive. This sleeve E normally rotates with the chuck body, but it can be held stationary during rotation of the chuck, and enables the operator, by applying to it an axial thrust, to set up such a frictional grip upon the divided nut C that the chuck can be screwed up until the jaws B^2 effectively engage the tool inserted therein. (*Sealed.*)

191,789. J. Hanlon, Wallasey, and A. Smith, Birkenhead. Scrap Metal Cutting Machines. (4 *Figs.*) November 7, 1921. —The invention relates to machines for cutting up heavy scrap metal, such as ship and boiler plates. According to the invention, which is designed to cut comparatively heavy gauge plates, the shaft, which carries the cutter bars D, is rotated continuously in the one direction by means of worm gearing E and the portion of the shaft between its end bearings is, in the main, of polygonal cross-section, having alternately disposed recesses d^3 and shouldered facings d^1, the cutter bars being detachably secured to the facings. The arrangement is such that whilst the longitudinal edge of the cutter bar D is obliquely disposed in relation to a plane passing through the axis of rotation, each point in the tip of the cutter rotates continuously in the same direction and is at an equal distance from the centre of rotation. In carrying

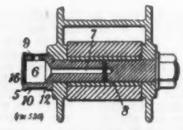




out the invention, the scrap metal is fed along a table B, or through a hopper, so as to pass over the upper and cutting edge of a horizontally disposed cutter bar C detachably secured to the inner edge of the table; beyond the inner edge, the cutter shaft is mounted with its axis parallel with, and preferably somewhat above, the plane of the upper cutting edge of the fixed cutter bar C; the under and cutting edges of the cutter-bars, as they move downwards as the shaft rotates, only just graze the upper and cutting edge of the fixed cutter C. The scrap metal is fed in any suitable manner between the fixed and rotating cutter bars, and is cut up into strips the maximum length of which is equal to the width of the machine, and the maximum width of which depends upon the radial projection of the cutter-bars D beyond the shaft on which they are mounted. (*Sealed.*)

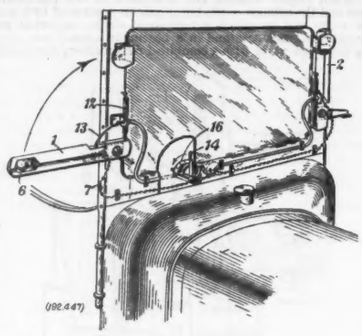
MOTOR ROAD VEHICLES.

191,530. S. S. Guy, Compton, near Wolverhampton. Shackle Bolts. (5 *Figs.*) November 7, 1921.—This invention has reference to shackle bolts of the kind in which the bolt head 5 is chambered at 6 to serve as an oil reservoir from which the oil finds its way to the bearing surface through ducts 7, 8 formed in the shank of the bolt. According to the invention, the filling



orifice 9 is closed by means of a spring clip 10 which is sprung over the head 5 and retained in place either by means of outside flanges 12 formed integrally with the head or by forming the latter of convex curvature in a direction at right angles to the plane of the clip. The head of the bolt is closed by a circular plate 16 secured in position by burring over the free edge of the hollow head. (*Sealed.*)

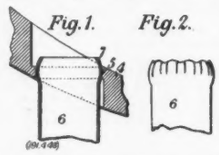
192,447. J. T. Hopkins, Fforestfach, Swansea. Direction Indicator. (3 *Figs.*) June 26, 1922.—The invention relates to an improved and simplified direction indicator for motor vehicles. According to the invention, the improved indicator comprises (*inter alia*) pivoted arms 1, 2, which at their extremities carry electric lamp bulbs 6 supplied with current by flexible wiring 7. The current is controlled either by an ordinary switch on the dashboard of the vehicle, or in cases where the movement of the arm automatically switches on current, a "master" switch may be provided. On one side of the pivot of each arm is attached a Bowden wire 13 for positively returning the arm into the inoperative position, and on the other side of the pivot is located a tension spring 12 which tends always automatically to force the arms into the operative position. The Bowden wire for each arm is brought to a common controlling device 14, 16, which consists of a double quadrant 16 provided with holes or recesses in which pins or projections on spring-pressed levers 14 connected



to the ends of the Bowden wires are adapted to engage, so that the levers 14 are securely held until released by a touch from the driver. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

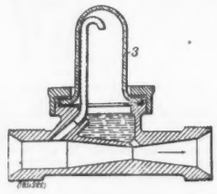
191,448. K. A. Spearing, Westminster. Water-Tube Boilers. (5 *Figs.*) October 8, 1921.—The invention relates to the mounting of tubes in opposed tube plates of steam boilers of the water-tube type. The invention consists in making the tubes 6 and tube plates 4 with their contacting surfaces so shaped that when a tube is entered into one of the tube plates it can be given a combined pivotal and sliding movement to position it between the tube plates, and when it is assembled in both tube plates it will contact with such plates over its whole circumference at both ends to facilitate the subsequent formation of fluid-tight joints between the tube and the tube plates. Pre fer-



ably, the holes 5 in the tube plates 4 are of cylindrical formation, and the tube 6 has a bulbous or spheroidal portion 7 at one end having a maximum transverse diameter substantially equal to that of the hole 5 in which it is to be inserted so that the tube can be entered in the hole at an angle and then given a combined pivotal movement until its free end is in alignment with the corresponding hole in the opposed tube plate, when it can be given an axial movement to enter its free end into the last-mentioned hole and bring the surfaces of the bulbous portion and corresponding hole into engagement, both ends being then expanded to ensure a fluid-tight connection in the usual manner. (*Sealed.*)

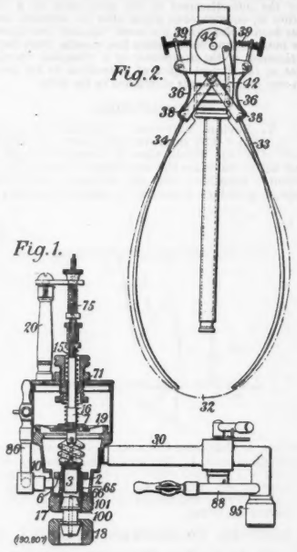
MISCELLANEOUS.

189,322. R. and W. Hawthorn, Leslie and Co., Limited, Newcastle-on-Tyne, G. Paterson, Newcastle-on-Tyne, and C. Thew, Newcastle-on-Tyne. Liquid Flow Indicator.



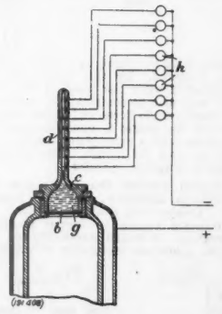
(2 *Figs.*) October 29, 1921.—The invention relates to an indicating device to be applied to a circulation system for liquids to indicate whether or not the liquid is flowing properly in the system. The improved device is of that type comprising a converging-diverging nozzle through which the liquid flows, and a pilot or by-pass connection between wide and narrow parts of the nozzle. The novel feature resides in the interposition in the connection of an indicator constituted by an air vessel 3 into which the pilot stream is delivered as a jet observable through the wall of the vessel. (*Sealed.*)

190,807. F. H. Adams, Walthamstow, London. Controlling Delivery or Discharge of High Pressure Air or Gas. (5 *Figs.*) September 29, 1921.—The delivery of high-pressure air or gas from a container or other source is controlled by apparatus of the kind having a load-controlled valve which cuts the supply off when the pressure of the discharged gas rises unduly, the gas passing through this valve passing to the outlet through an intermediate regulating chamber having outlets controlled by a second valve operated by the mechanism which operates the first valve. In the apparatus shown, an intermediate receiver 10, Fig. 1, communicates through a valve-controlled tube 2 and a union tube 100 with a storage cylinder (not shown) of compressed gas, and communicates also through a pipe 30 controlled by a hand valve, with a bag 32, Fig. 2, connected with the pipe by a coupling 95. A valved pipe 86 leading from the receiver 10, and a valved pipe 88 leading to the pipe 30 communicate with a device for mixing the gas with chloroform or ether. The union 100 is formed with conical ends and with its nuts 17, 18, is reversible. The tube 2 is formed with inlet ports 66 controlled by a spring-pressed hollow valve 65 containing a reversible block 3 controlling the port 101 of the union 100. The valve is automatically closed by rise of pressure in the receiver 10 through a lazy tongs pivoted at one end to a rod 7 secured to a diaphragm 19 covering the receiver, and at the other end connected by a pivot to a nut screw 6 screwed on the tube 2. The pressure at which



the valve is closed is determined by springs 15, 16, surrounding the rod and butting against a member 71 provided with a gland through which it passes. The valves may be positively actuated by Bowden wire mechanism, in which the cable 75 is secured to the top of the rod 7, while the flexible tube is secured to a pillar 20, motion being communicated by a lever or a spring-controlled bolt having a pin entering one series of notches. The gas bag, Fig. 2, is enclosed within levers 33, 34, connected to a forked member 38 operating an inlet plug valve 44 through a link 42, in opposition to the action of the levers 36, pressed by adjustable springs 39. The gas enters the bag through a stopped perforated silencing pipe, and passes out by a second pipe and a passage in the valve casing to a mouth-piece connection. A spring-controlled piston or collapsible bellows may replace the diaphragm and the rotary plug valve of the gas bag may be replaced by a valve of another kind. (*Accepted January* 10, 1923.)

191,408. A. M. Low, Feltham. Apparatus for Estimating or Indicating Varying Pressures. (1 *Fig.*) July 2, 1918.—The invention consists in apparatus for the estimation or indication of varying pressures, comprising a diaphragm *b* or other device susceptible to variations in pressure, a tubular or other vessel *c* closed at one end and fitted at the other with the dia-



phragm *b*, and having one part *d* of relatively small diameter compared with the other. A mobile or movable conductor *g* is arranged within the vessel *c* adapted to complete the circuits of one or more of a series of indicators and/or recorders *h*, whereby an indication of the movements, or of the maximum deflection, of the diaphragm may be obtained. (*Sealed.*)

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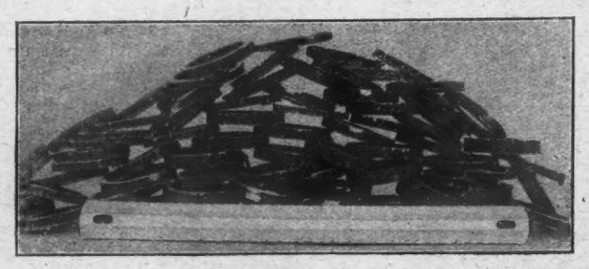

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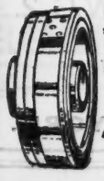

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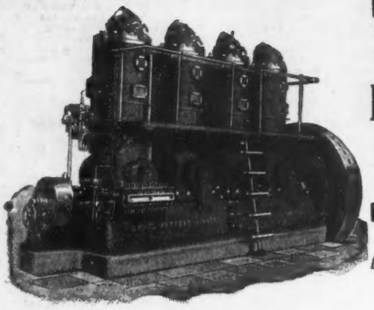

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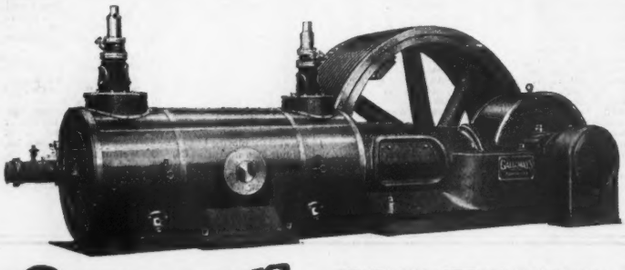

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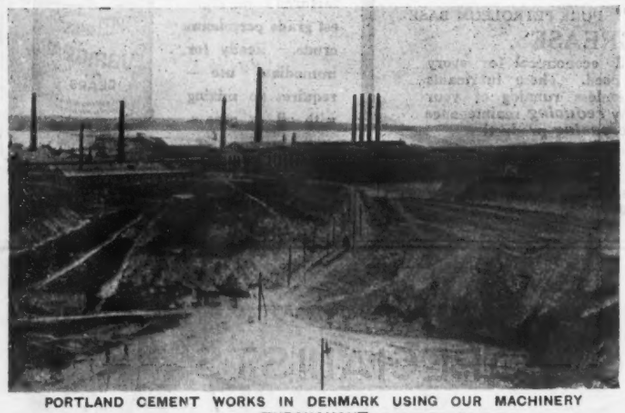

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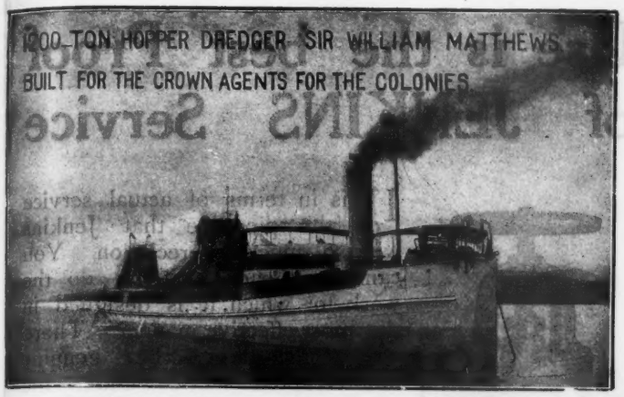

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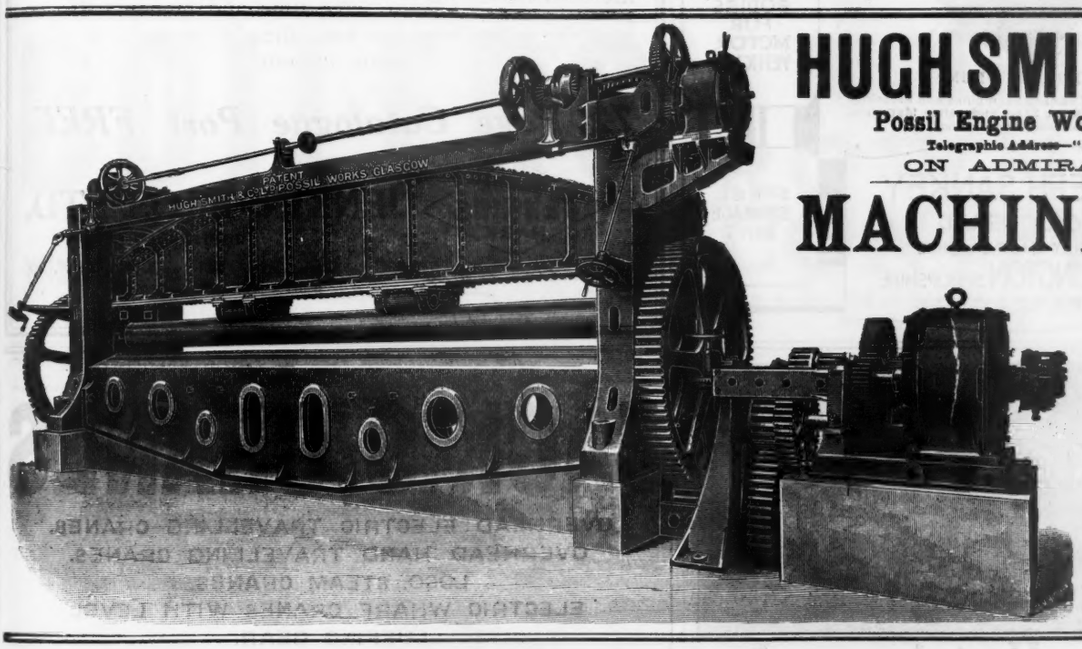

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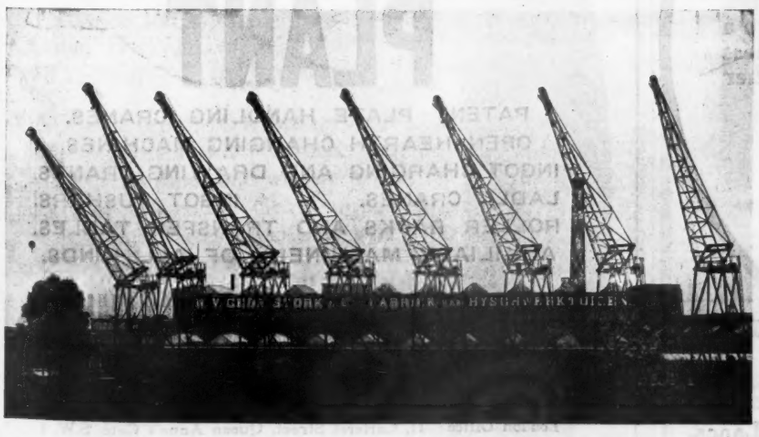

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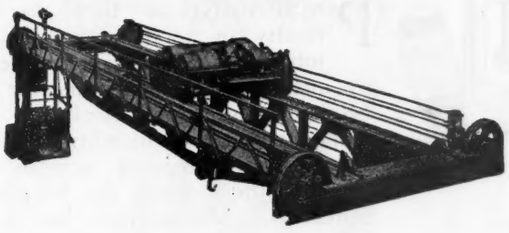

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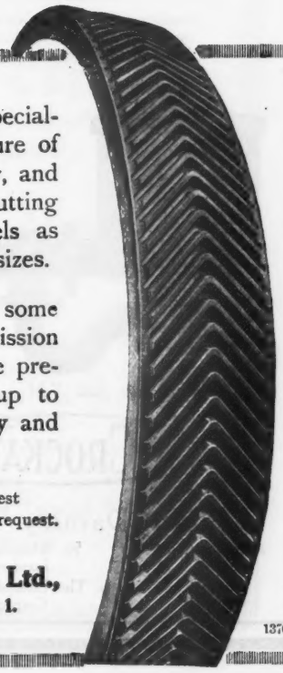

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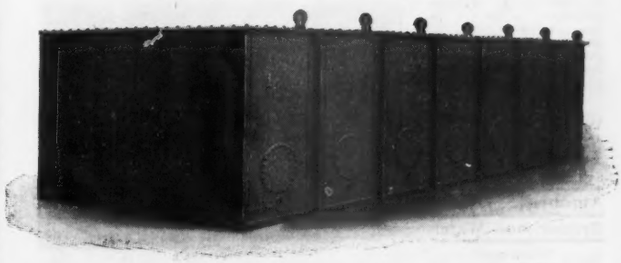

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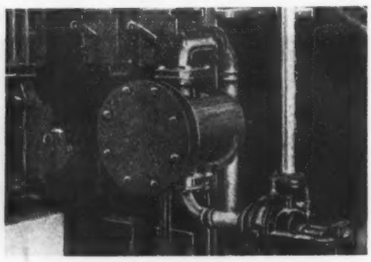

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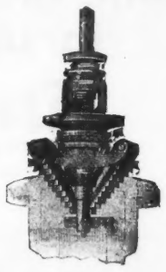

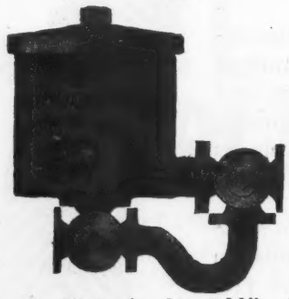

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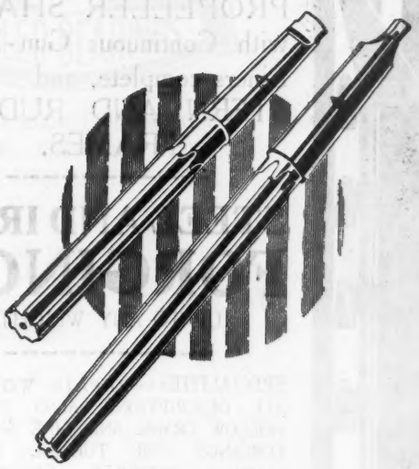

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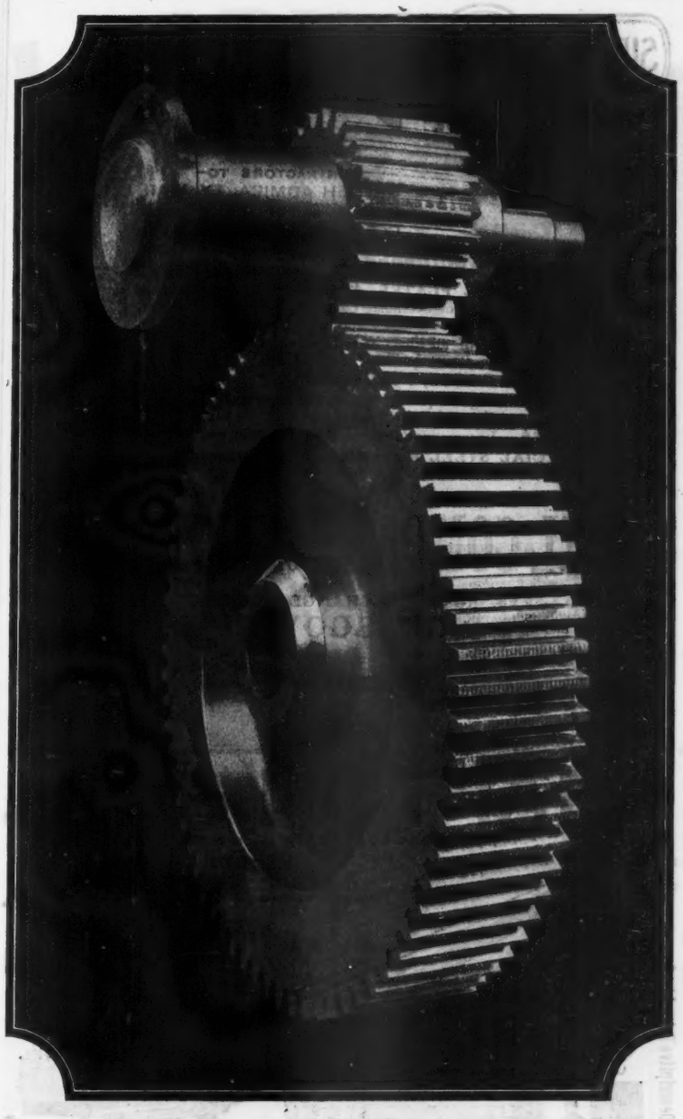

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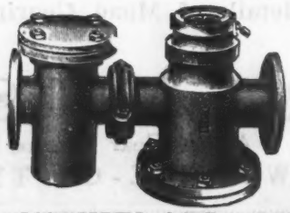

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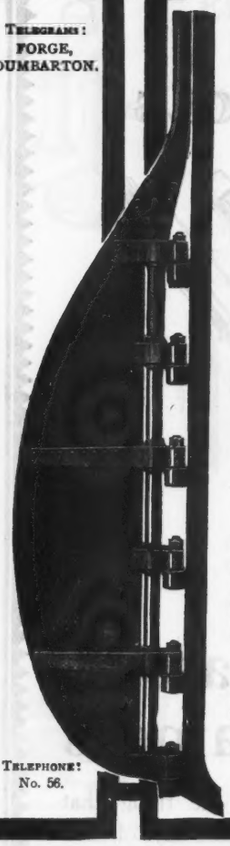

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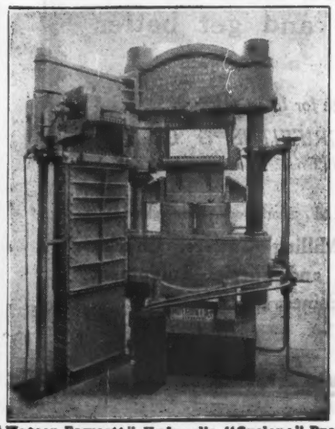

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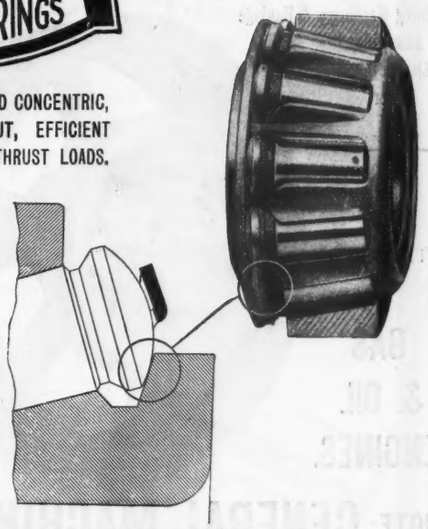

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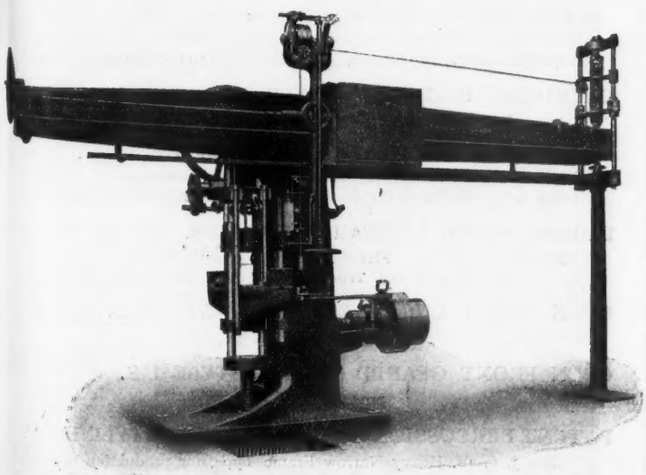

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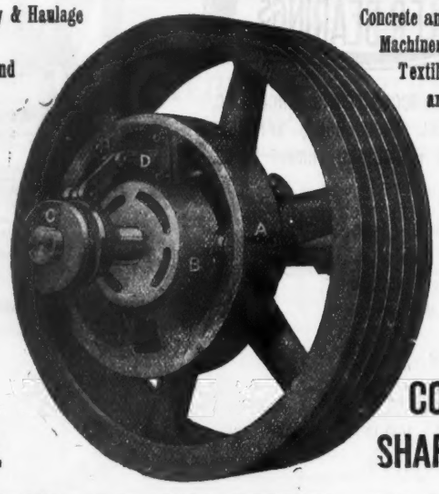

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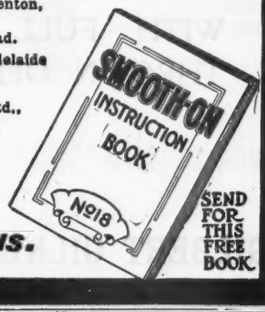

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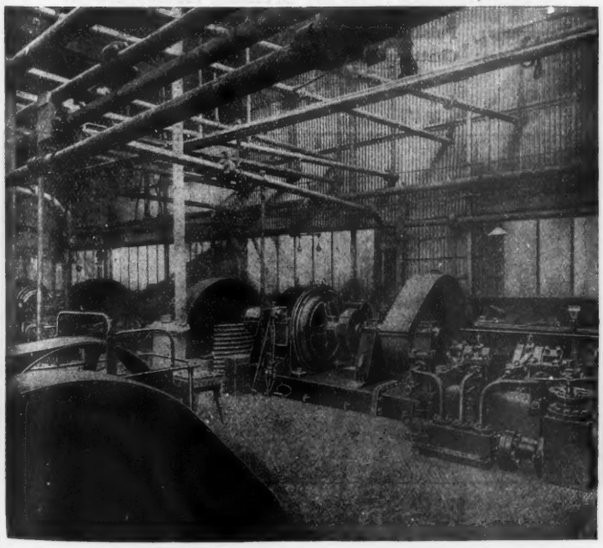

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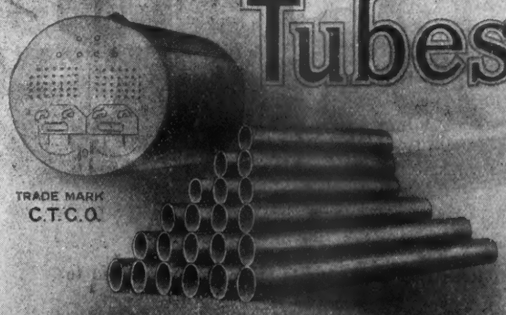

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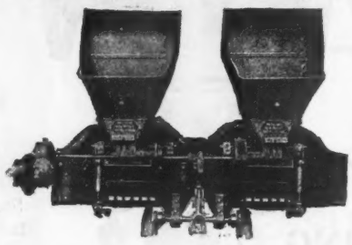

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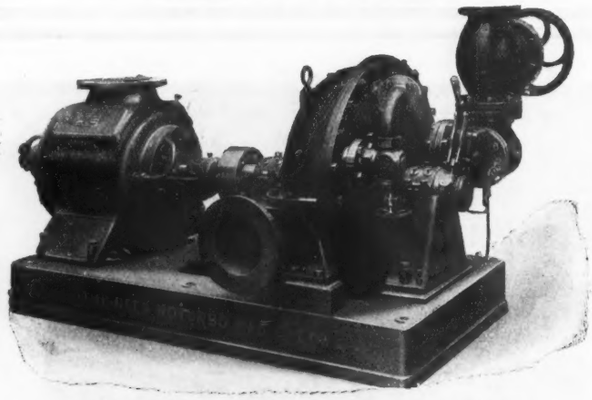

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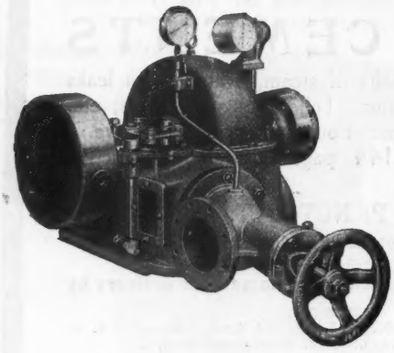

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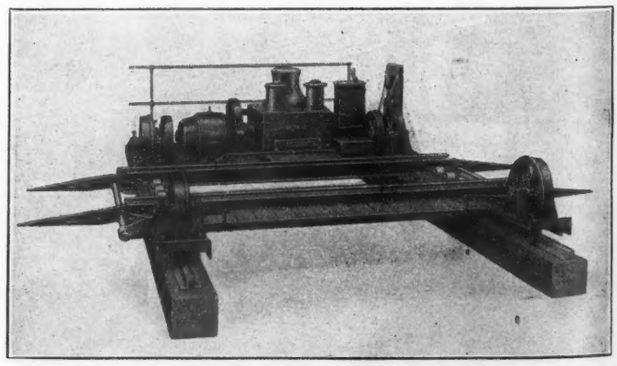

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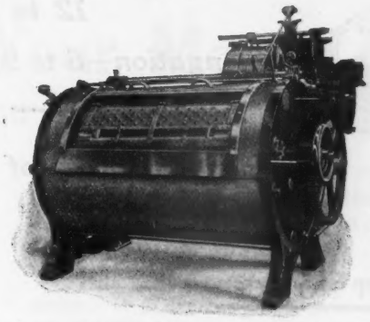

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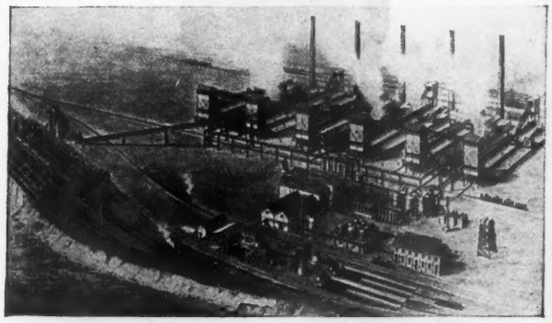

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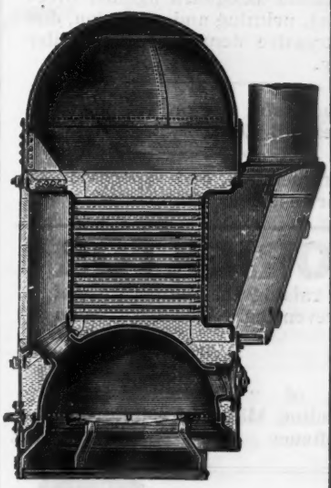

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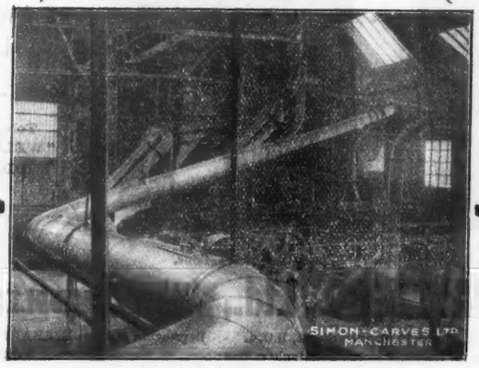

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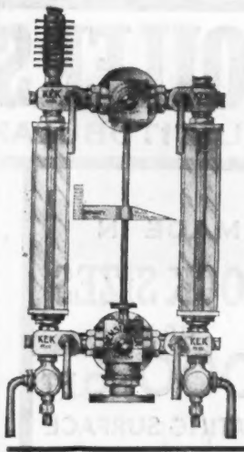

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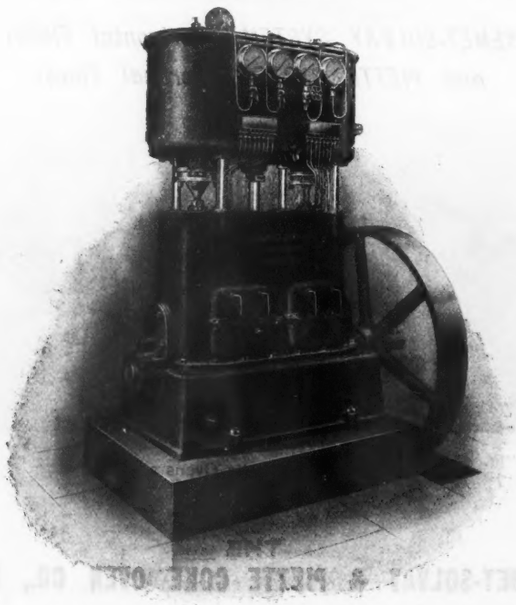

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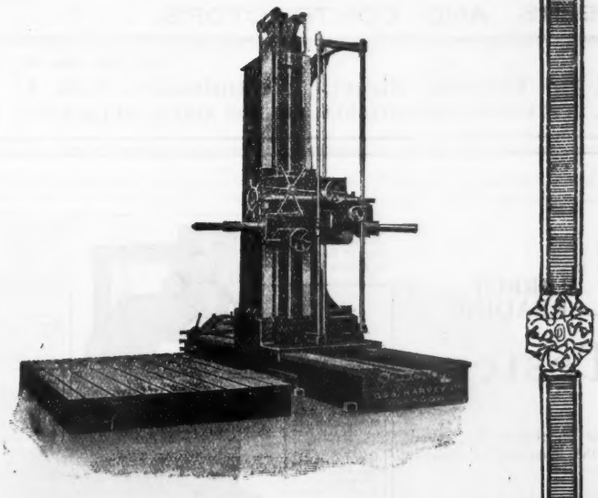

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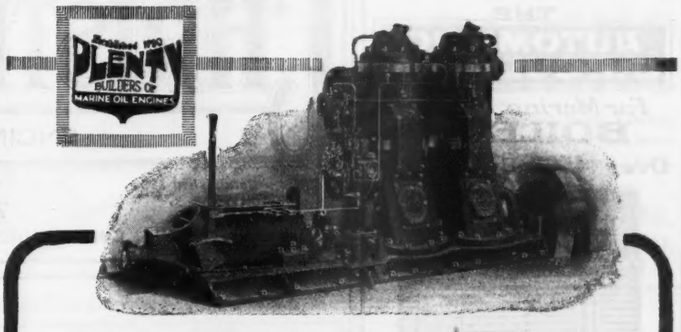

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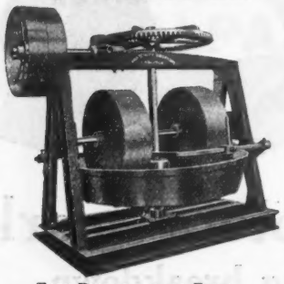

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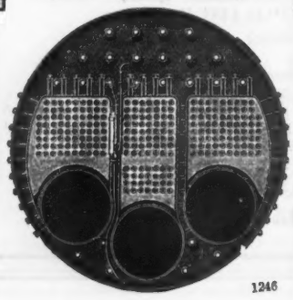

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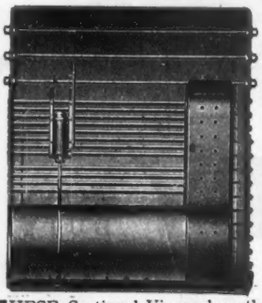
For Marine & Land
BOILERS
Over 4500 Sets in Use



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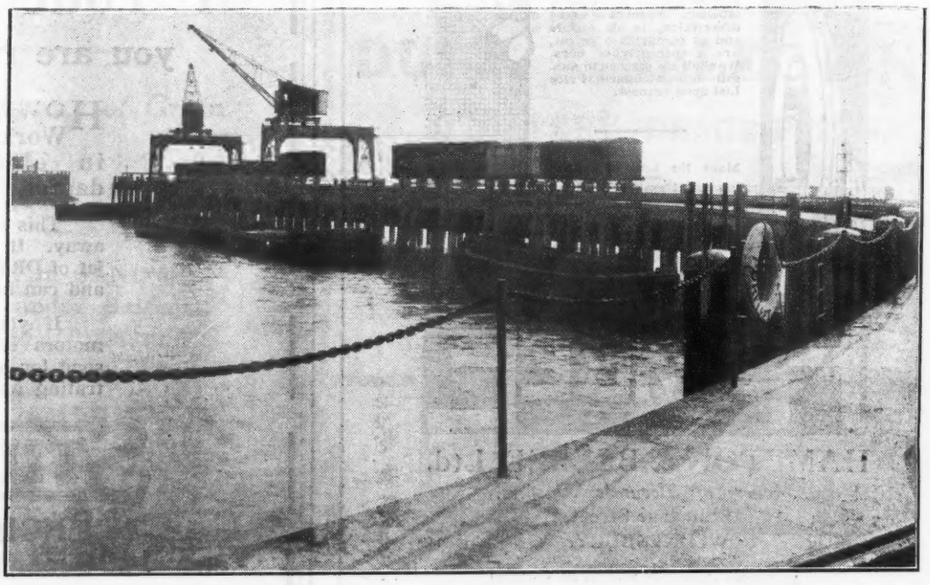

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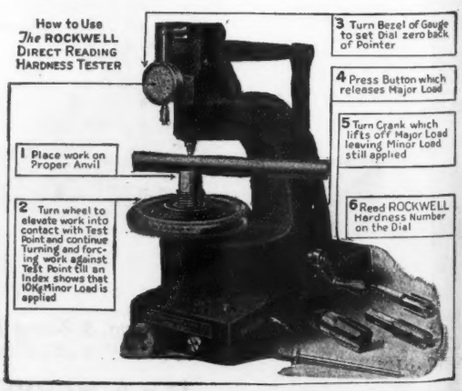
How to Use The ROCKWELL DIRECT READING HARDNESS TESTER
1 Place work on Proper Anvil
2 Turn wheel to elevate work into contact with Test Point and continue Turning and forcing work against Test Point till an Index shows that 10Kg Minor Load is applied
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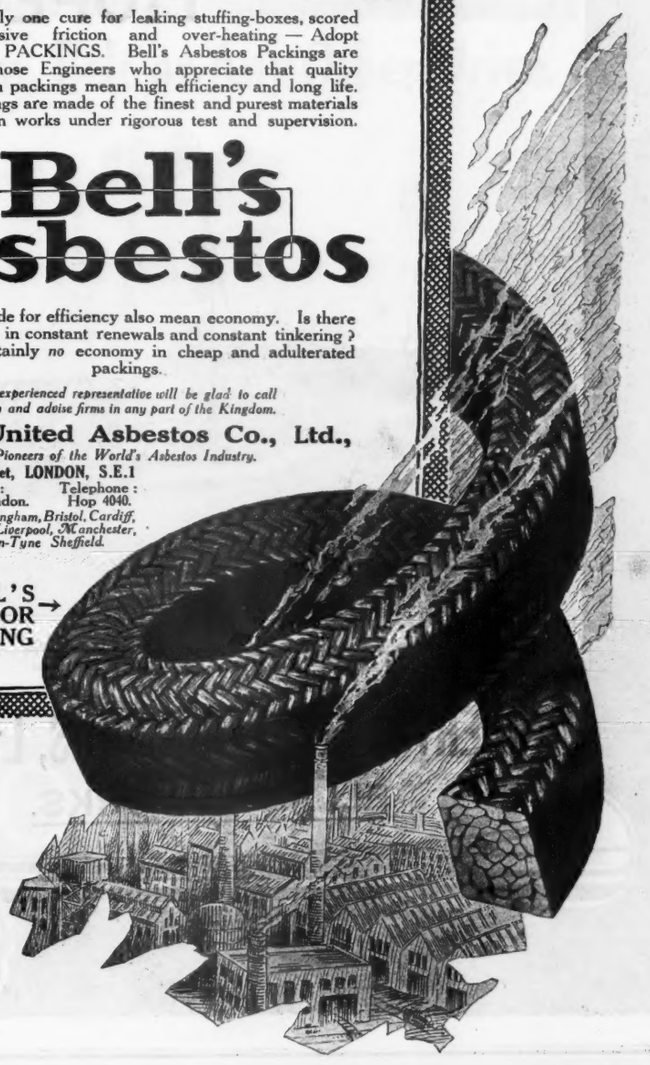

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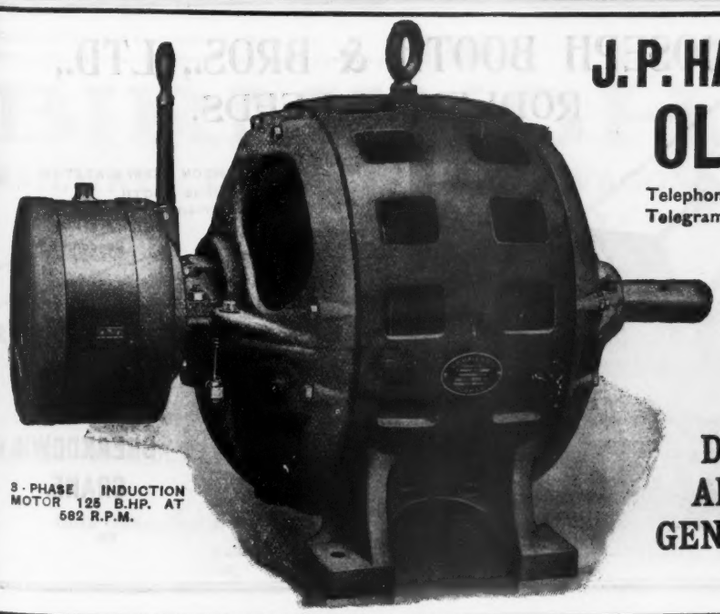

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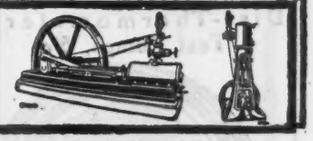

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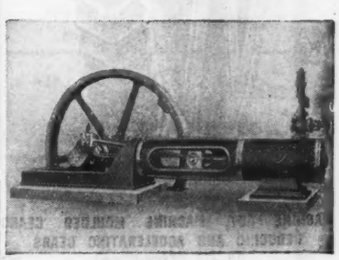

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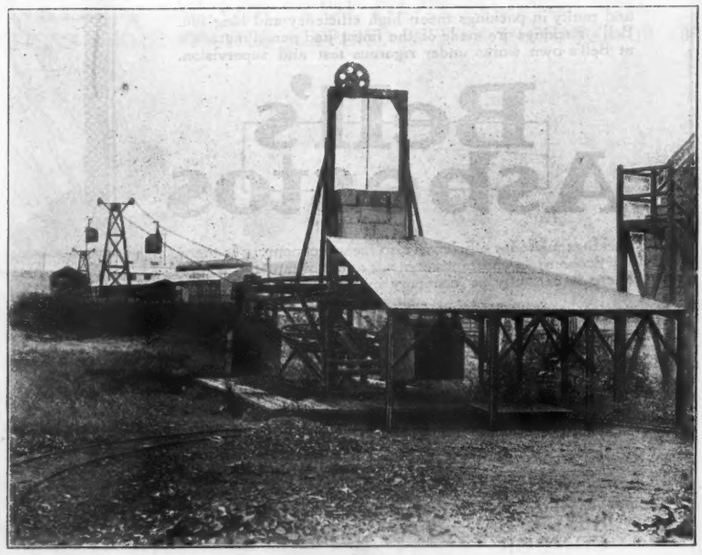

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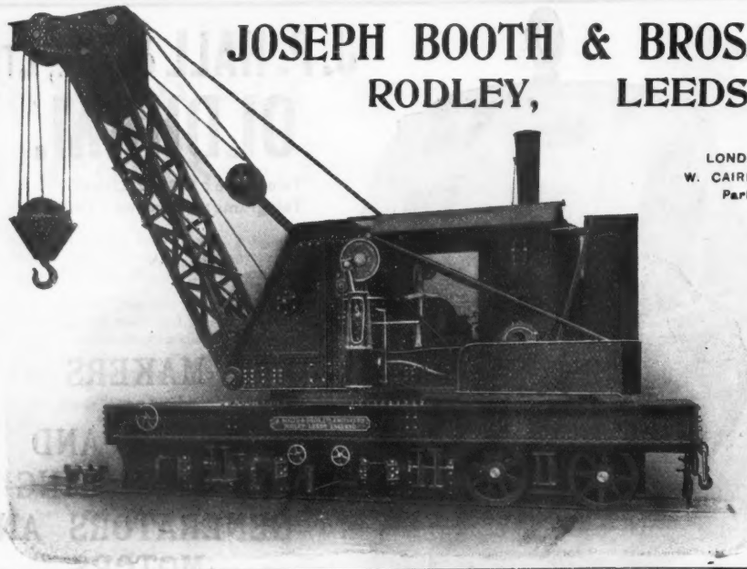

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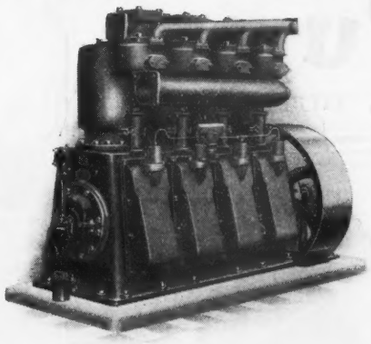

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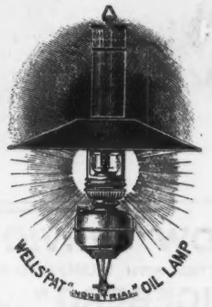

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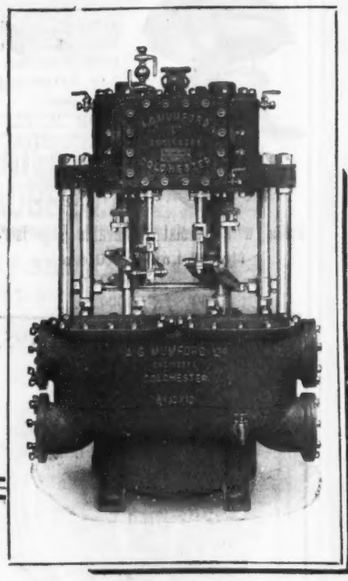

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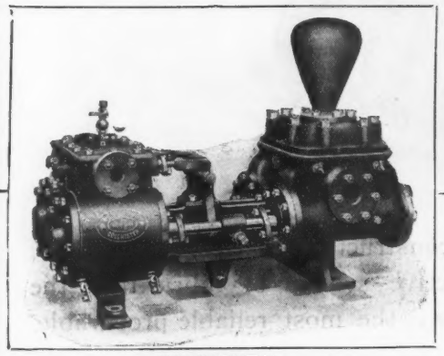

HORIZONTAL
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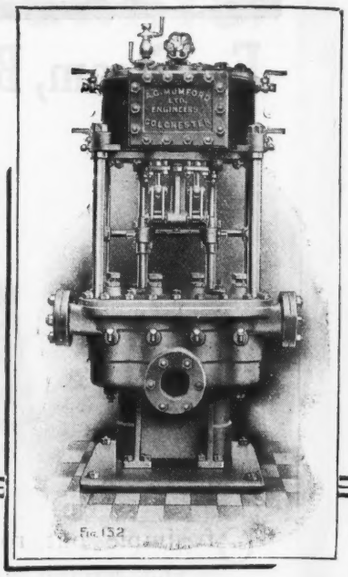

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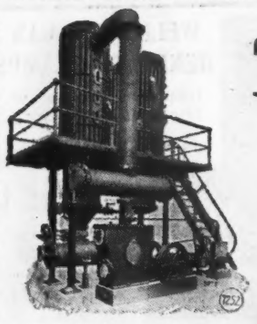

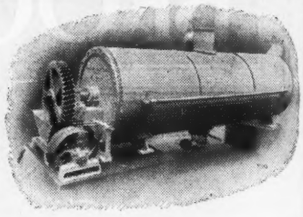

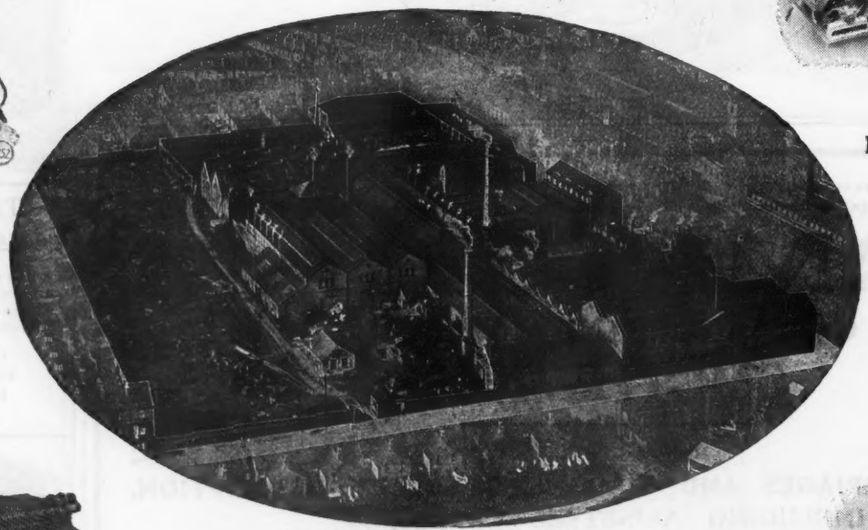

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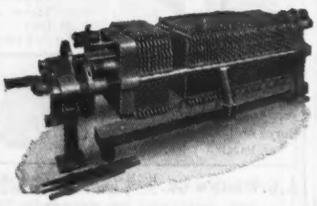

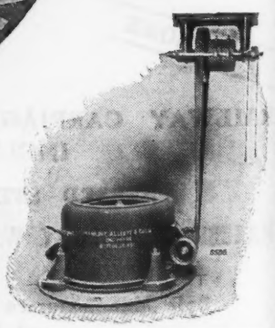

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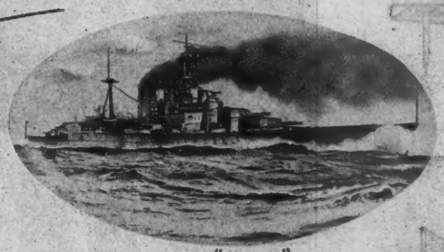

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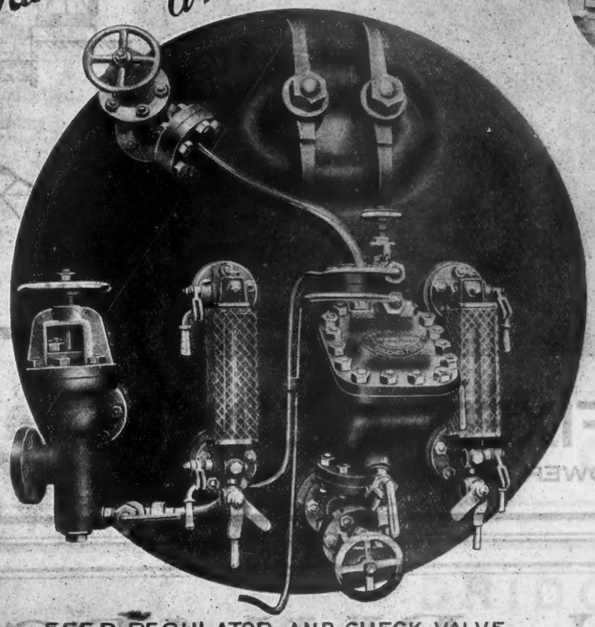

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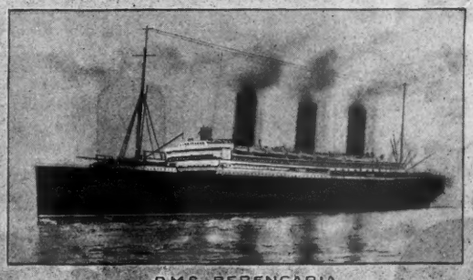

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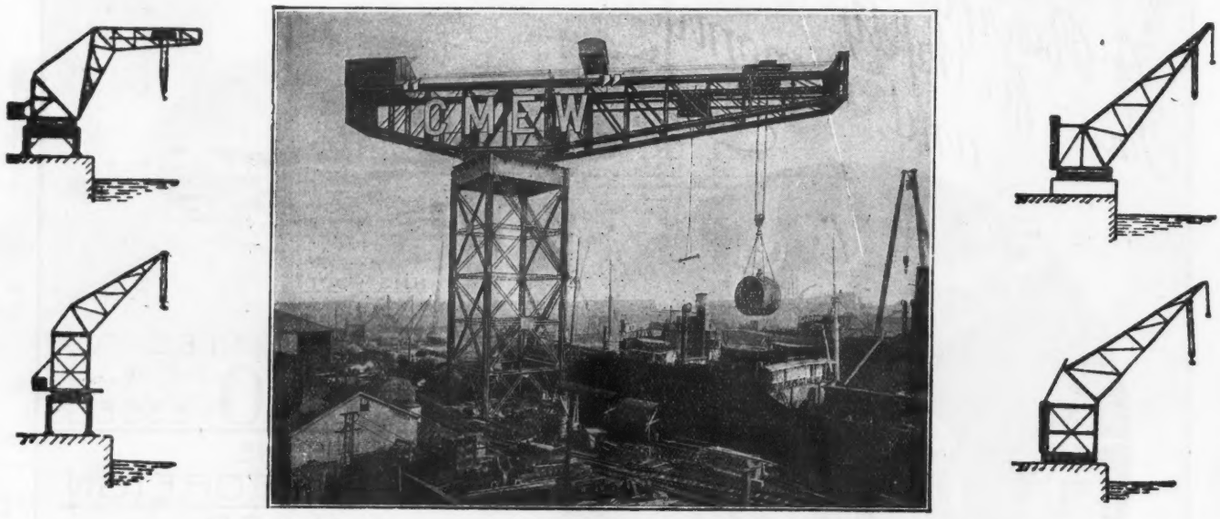

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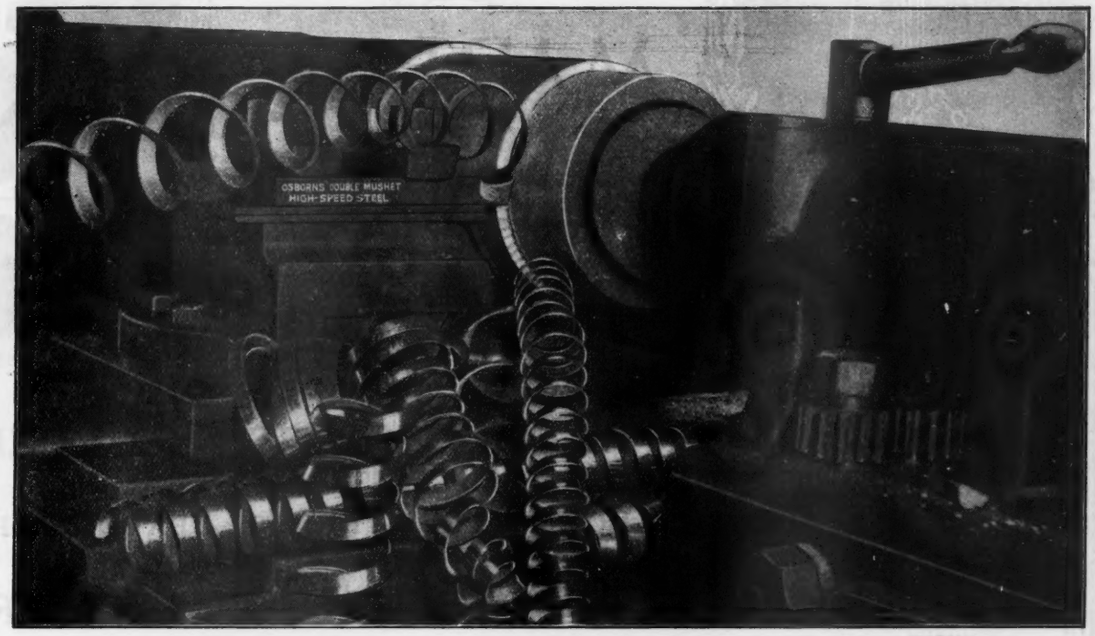

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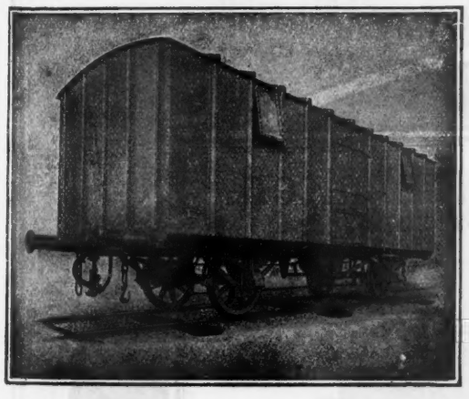

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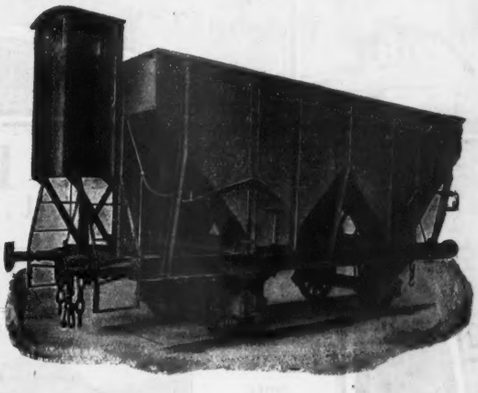

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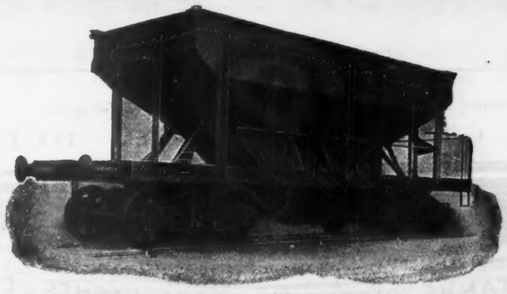

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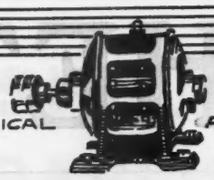

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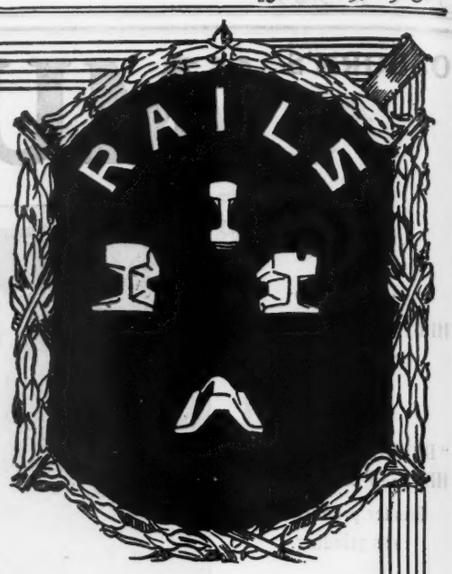

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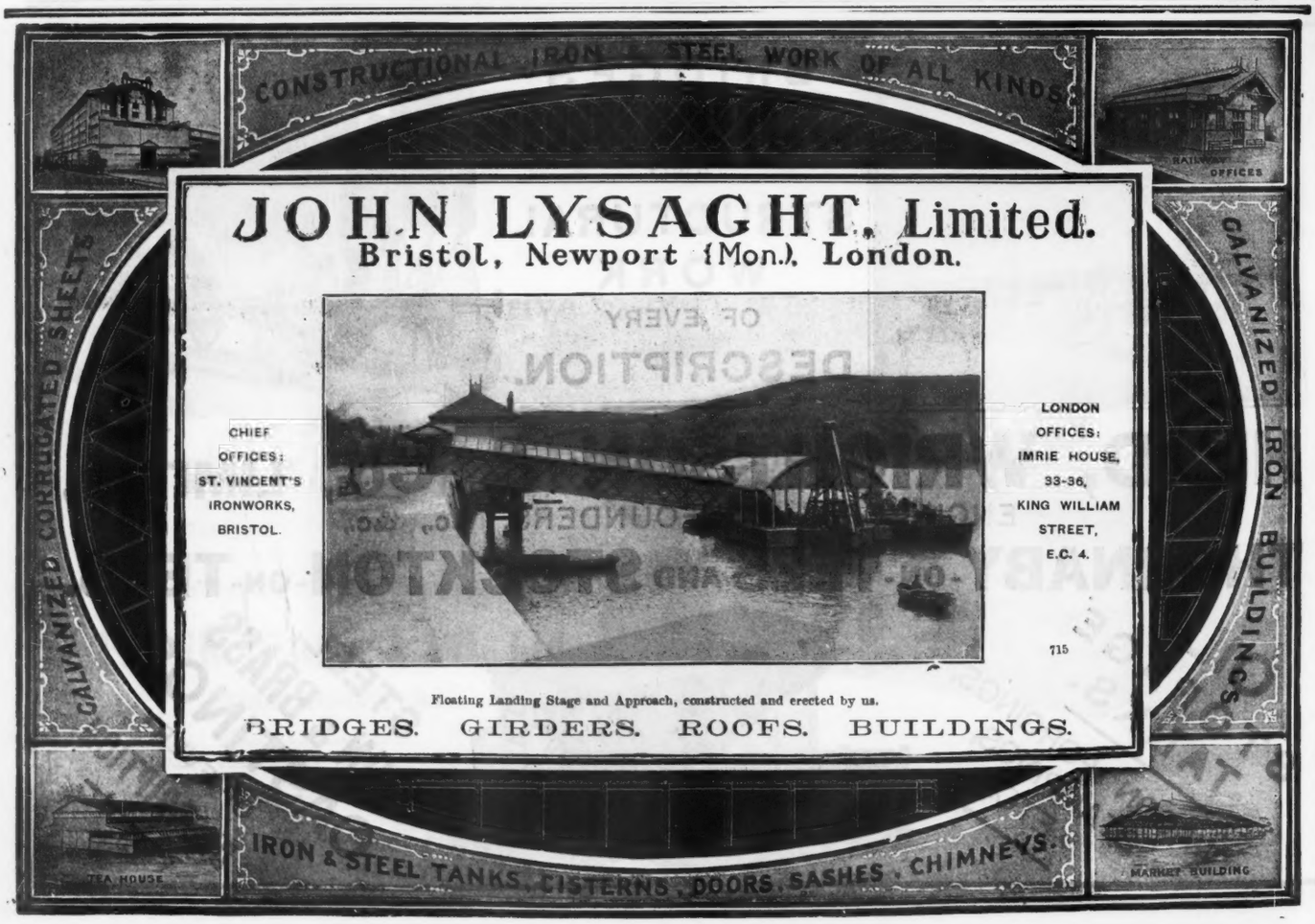
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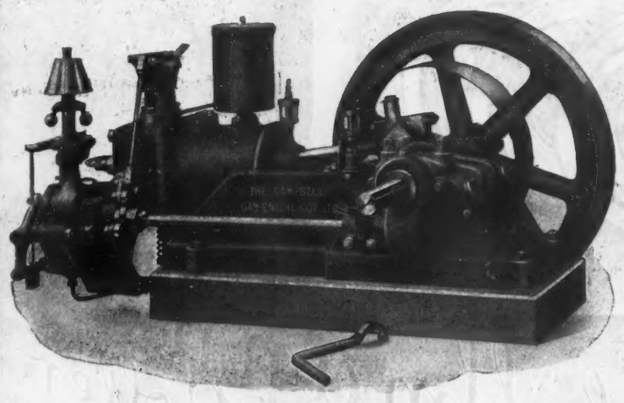

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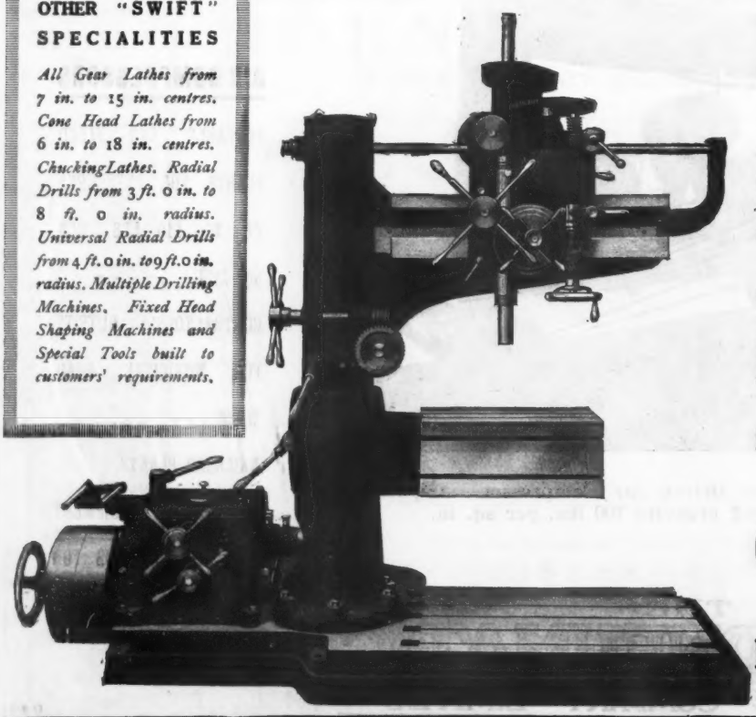

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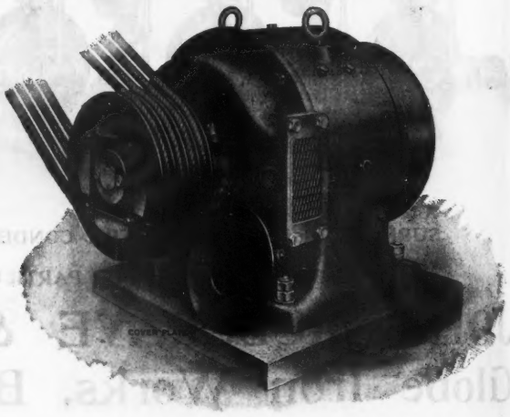

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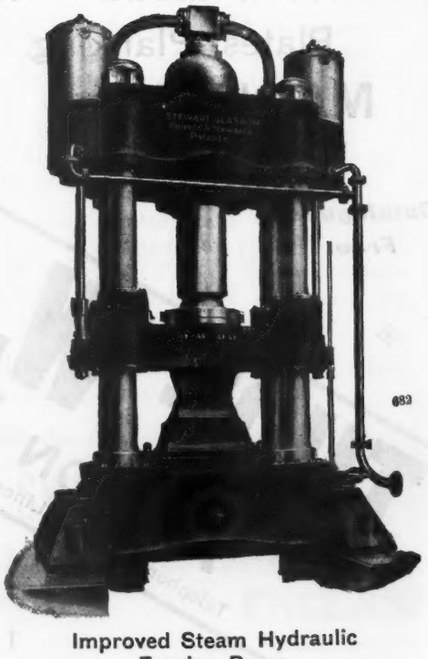

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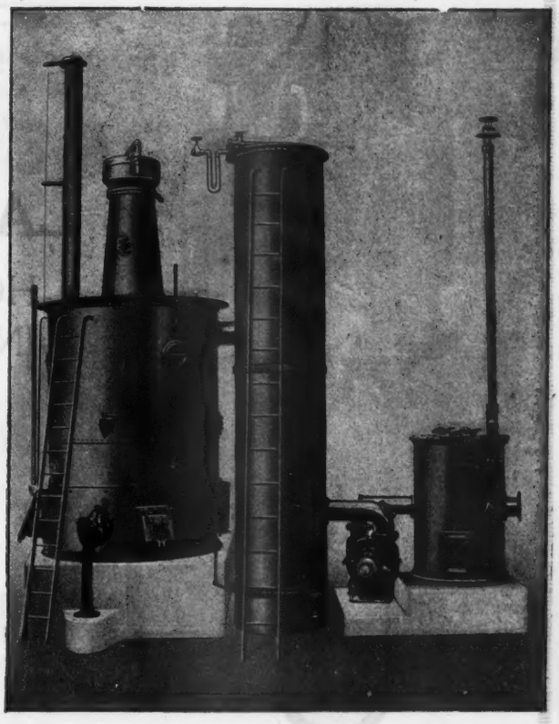

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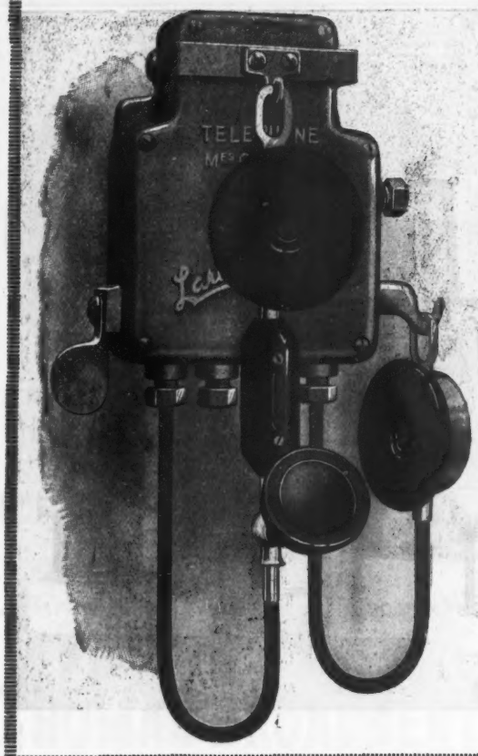

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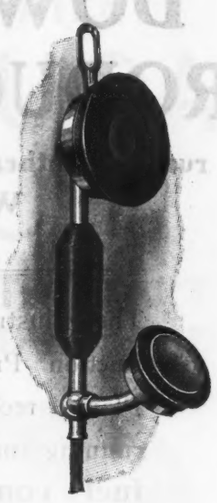

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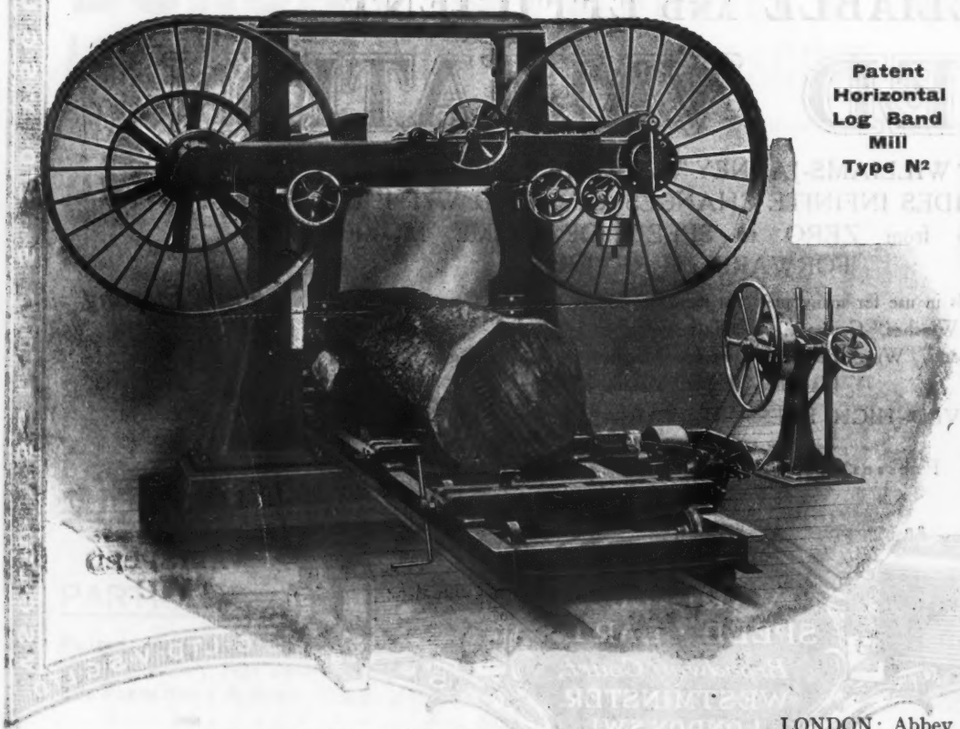

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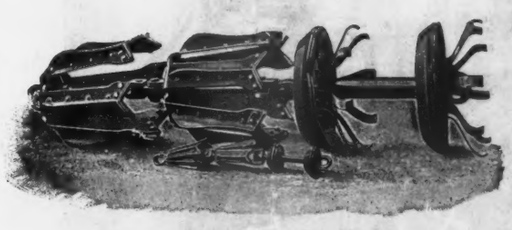

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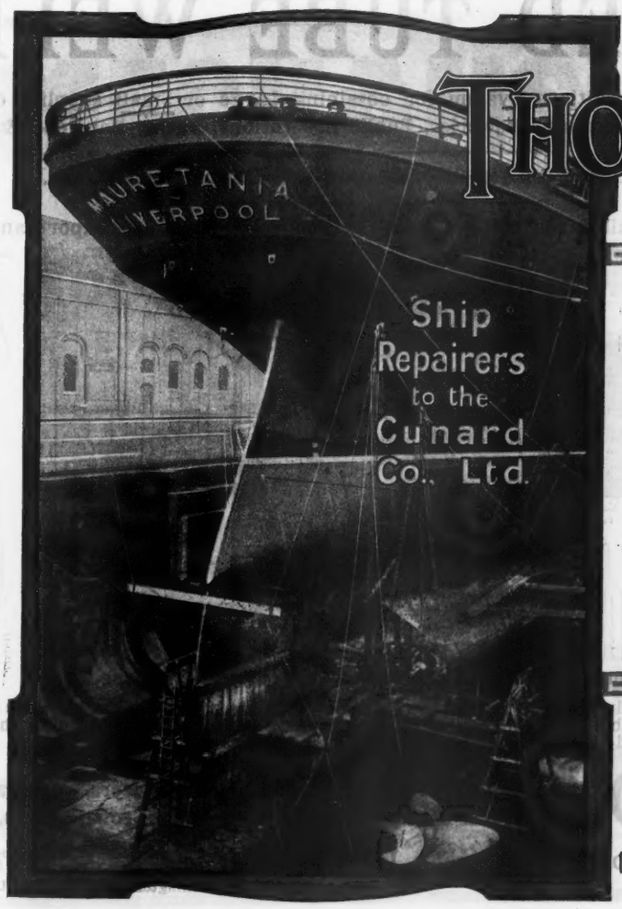

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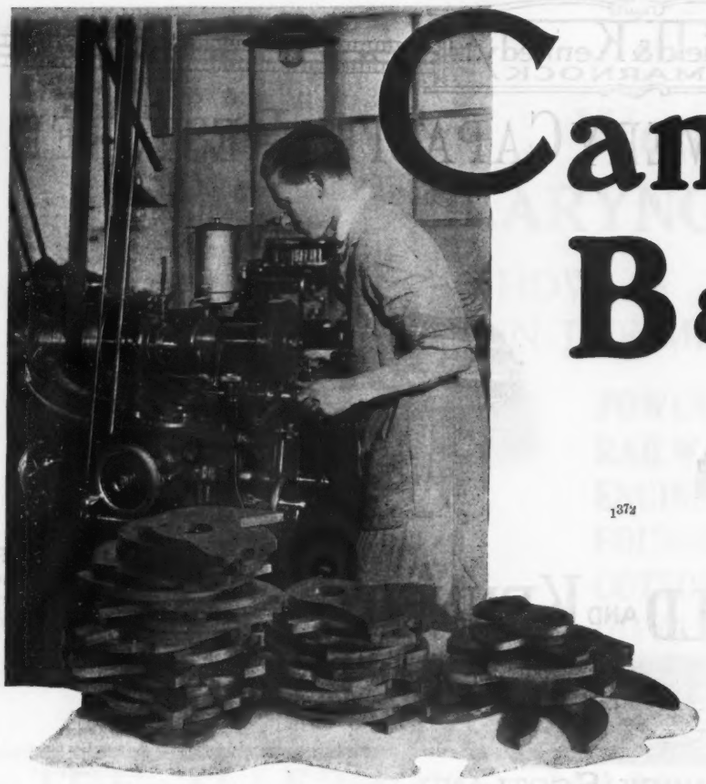

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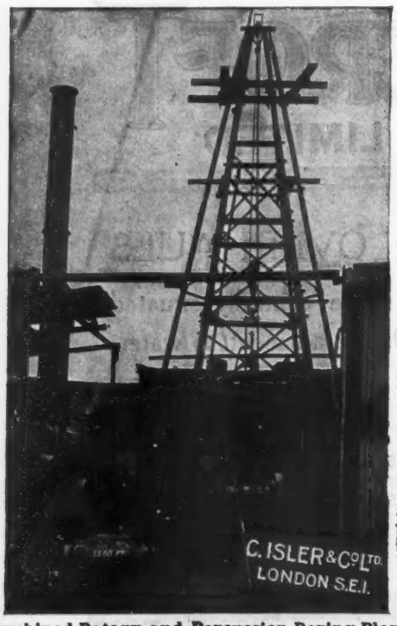

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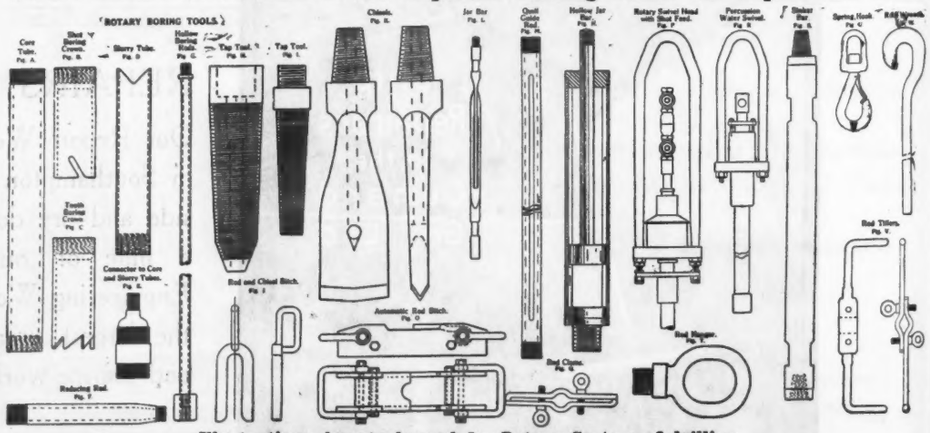

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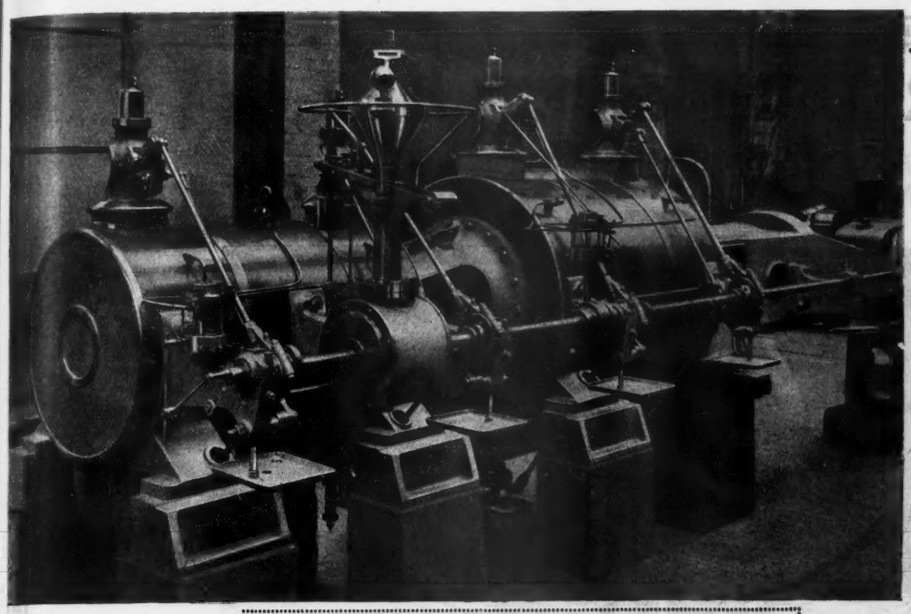

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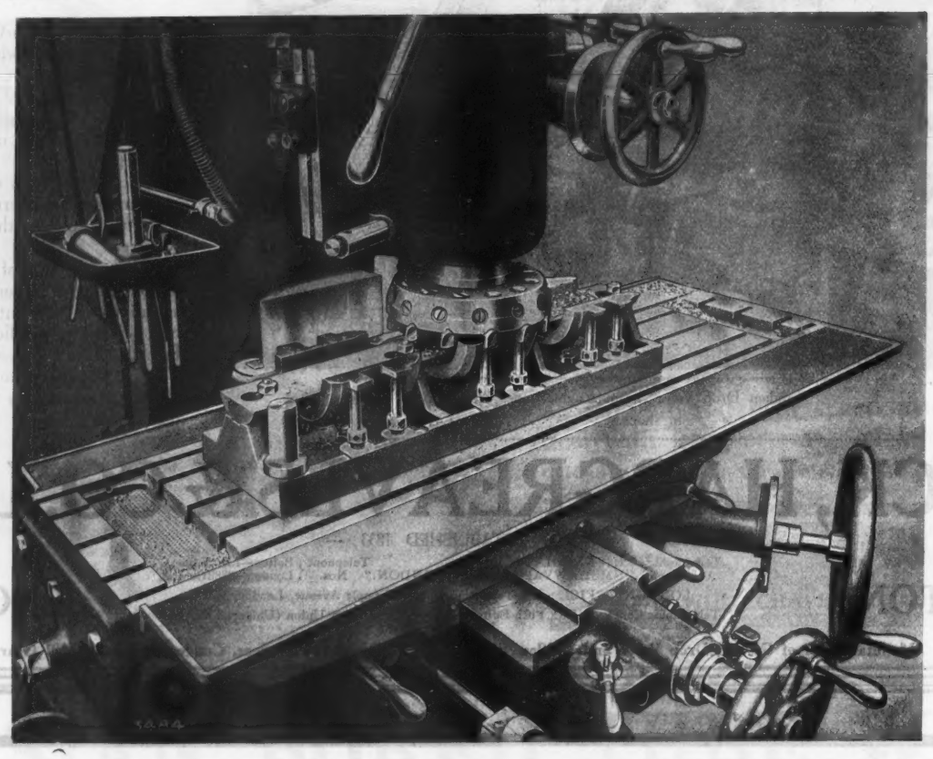

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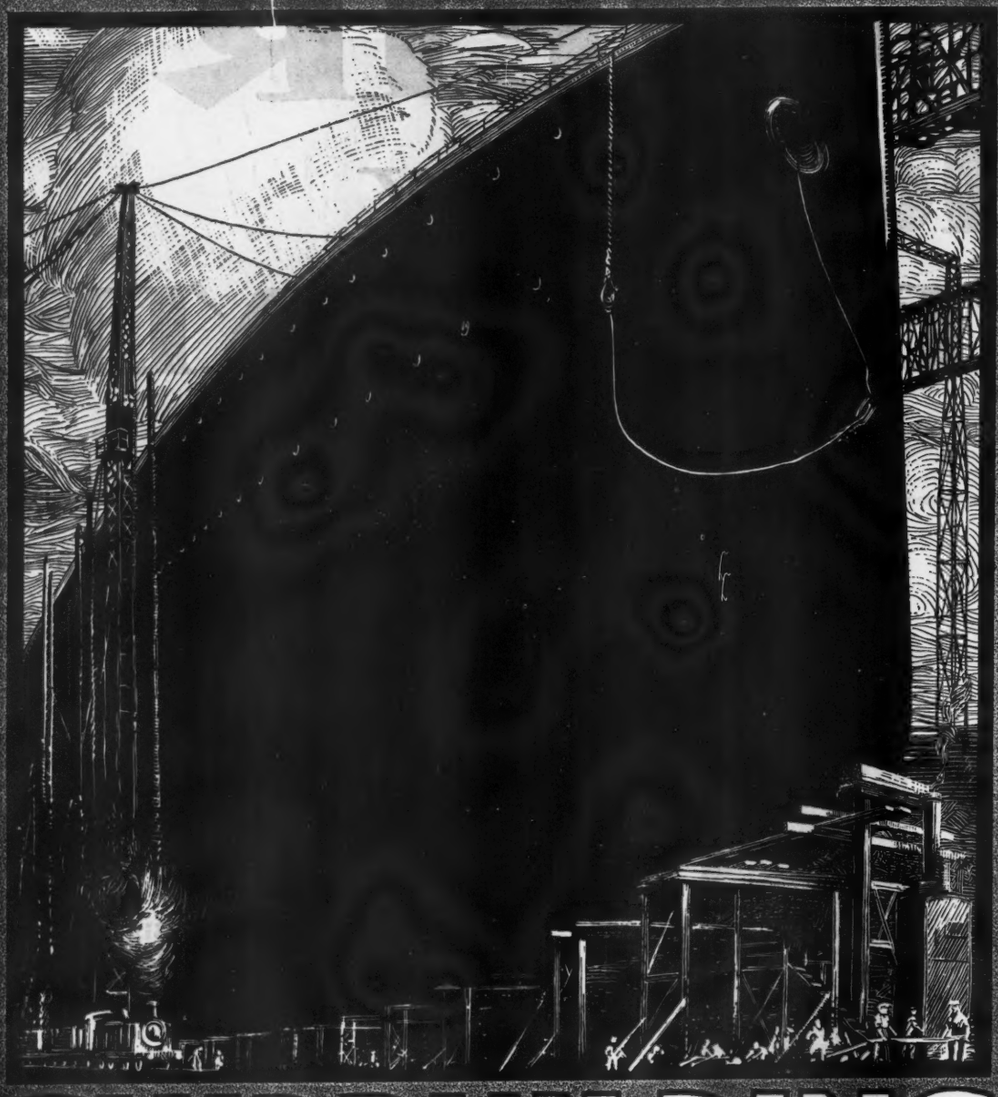

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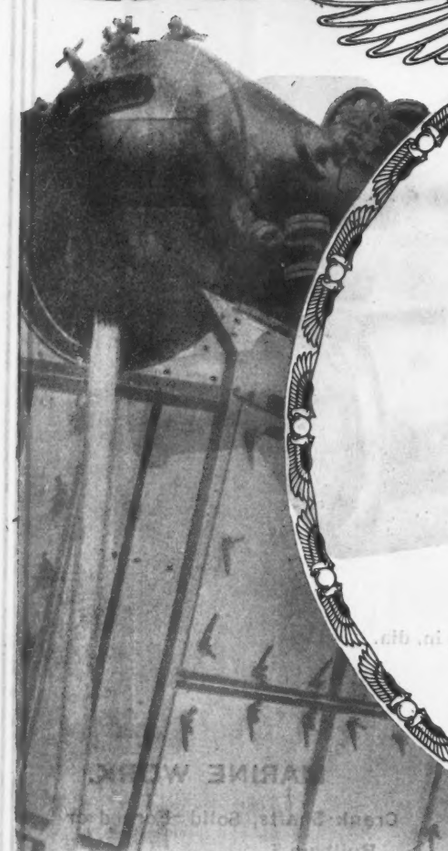

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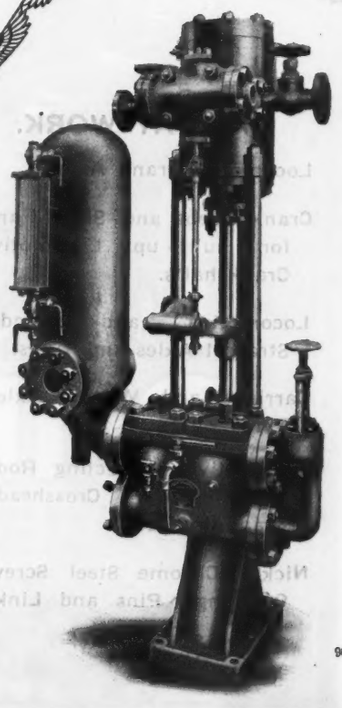

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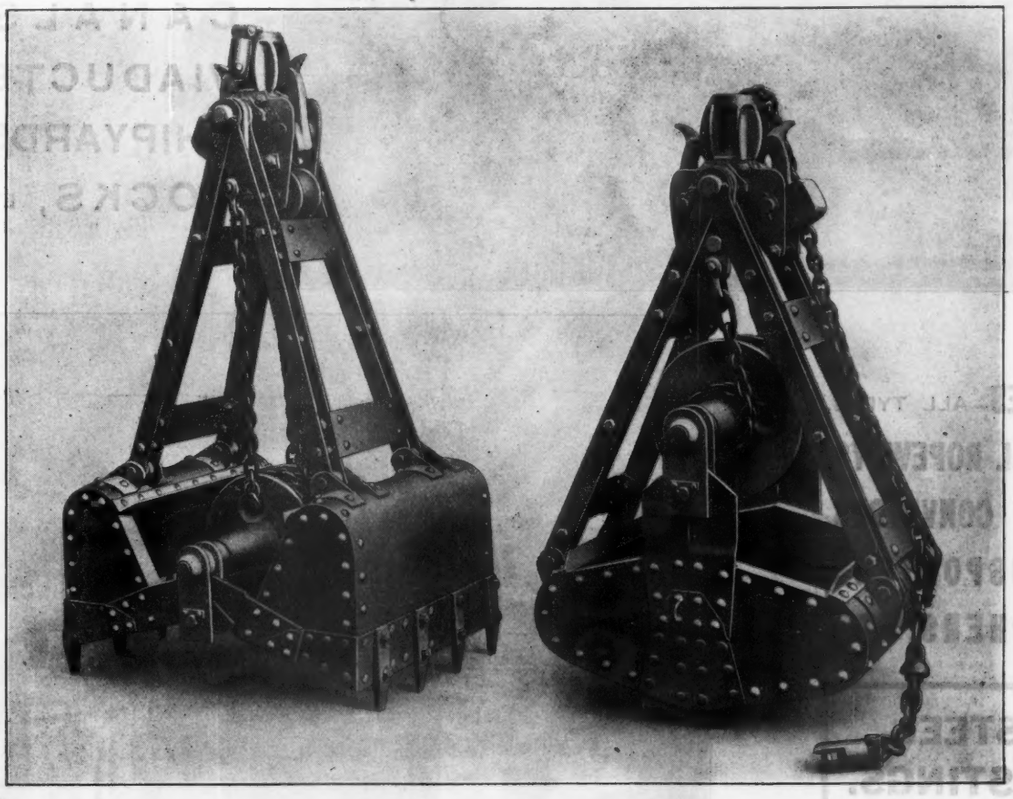

Fig. 1346.

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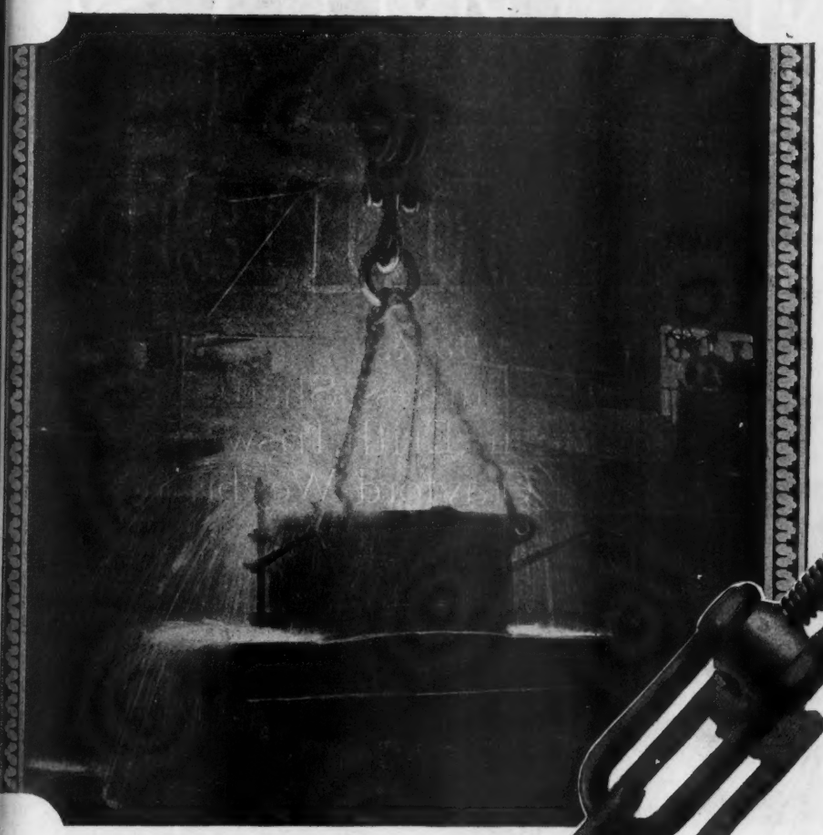

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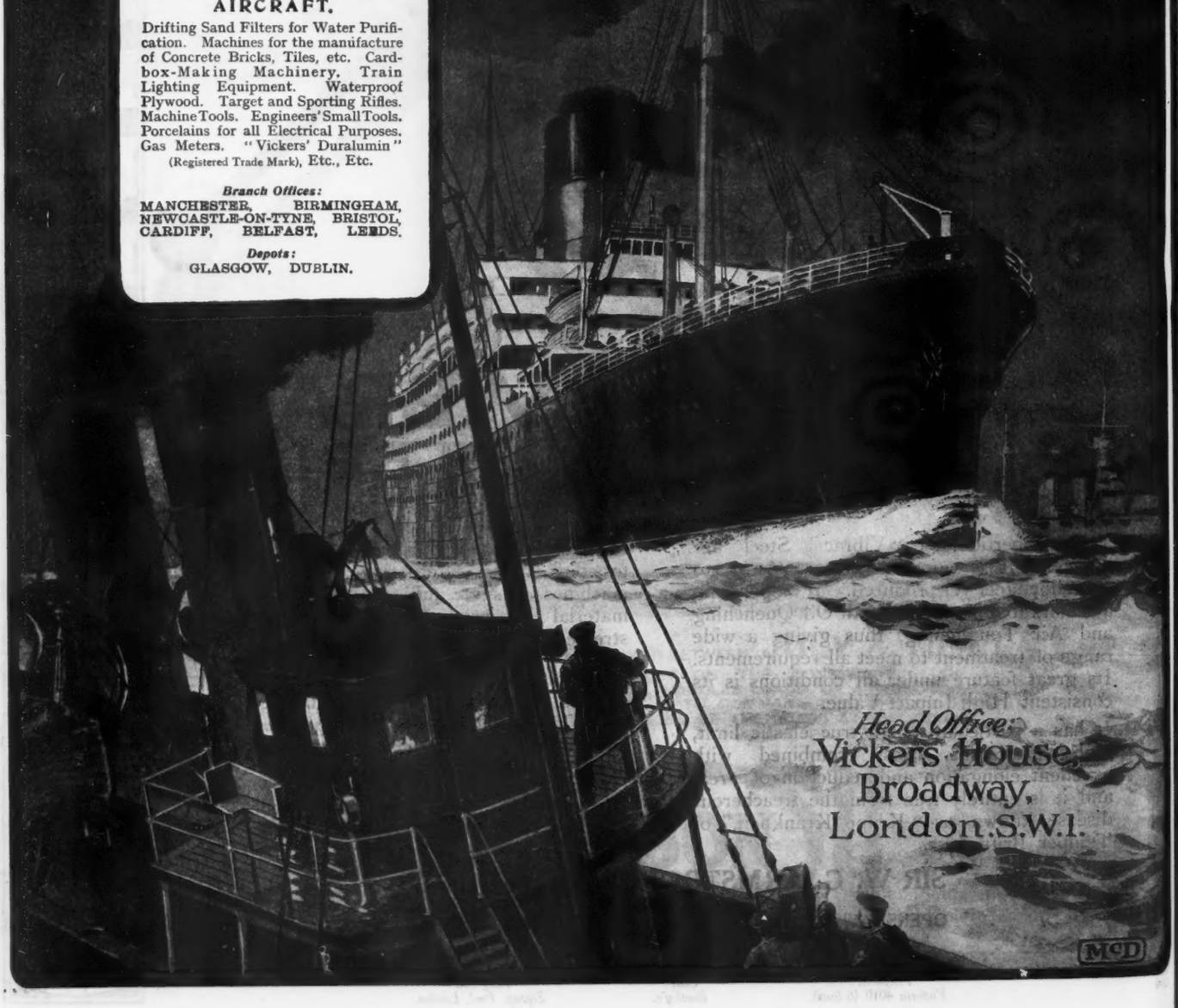

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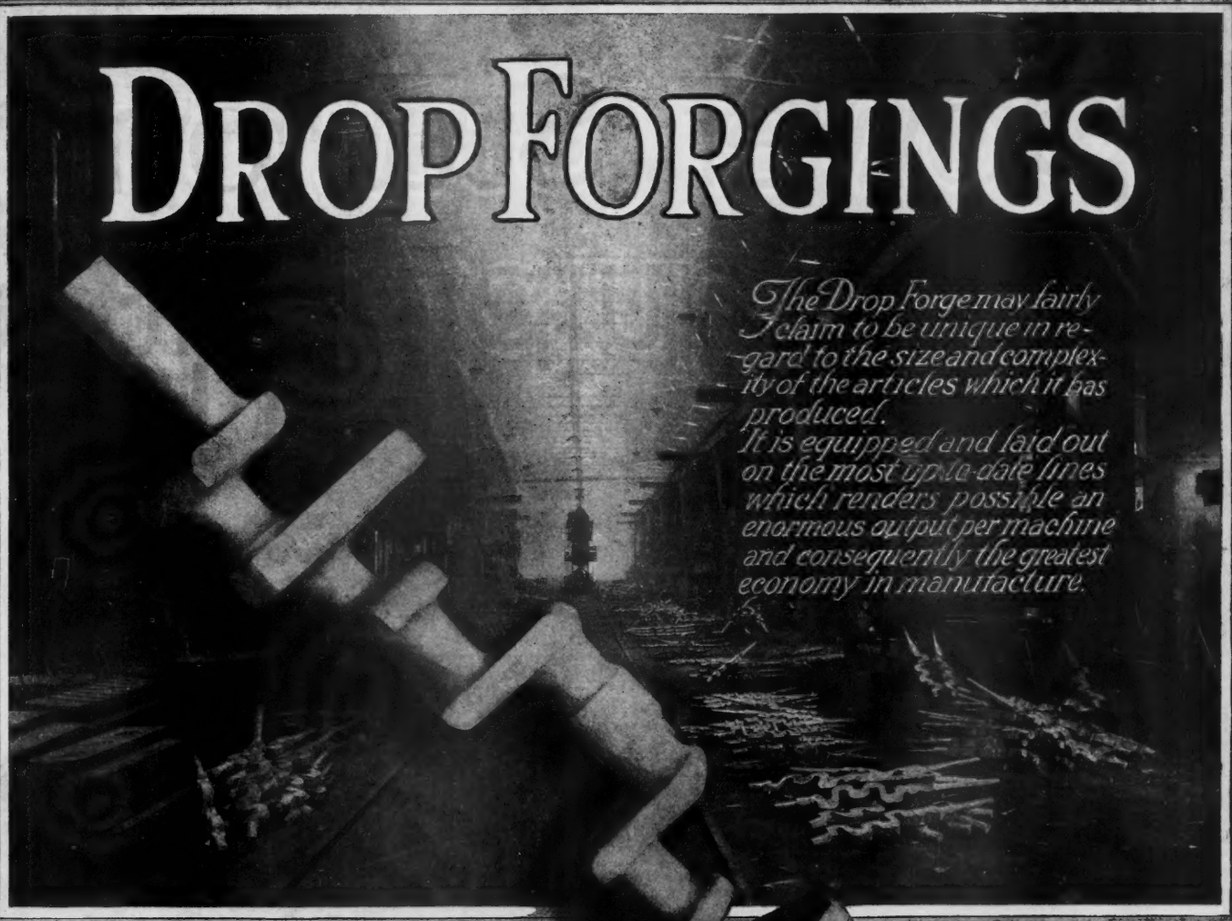

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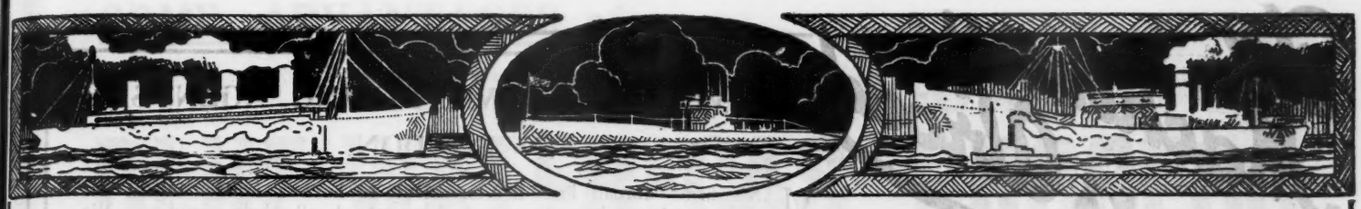

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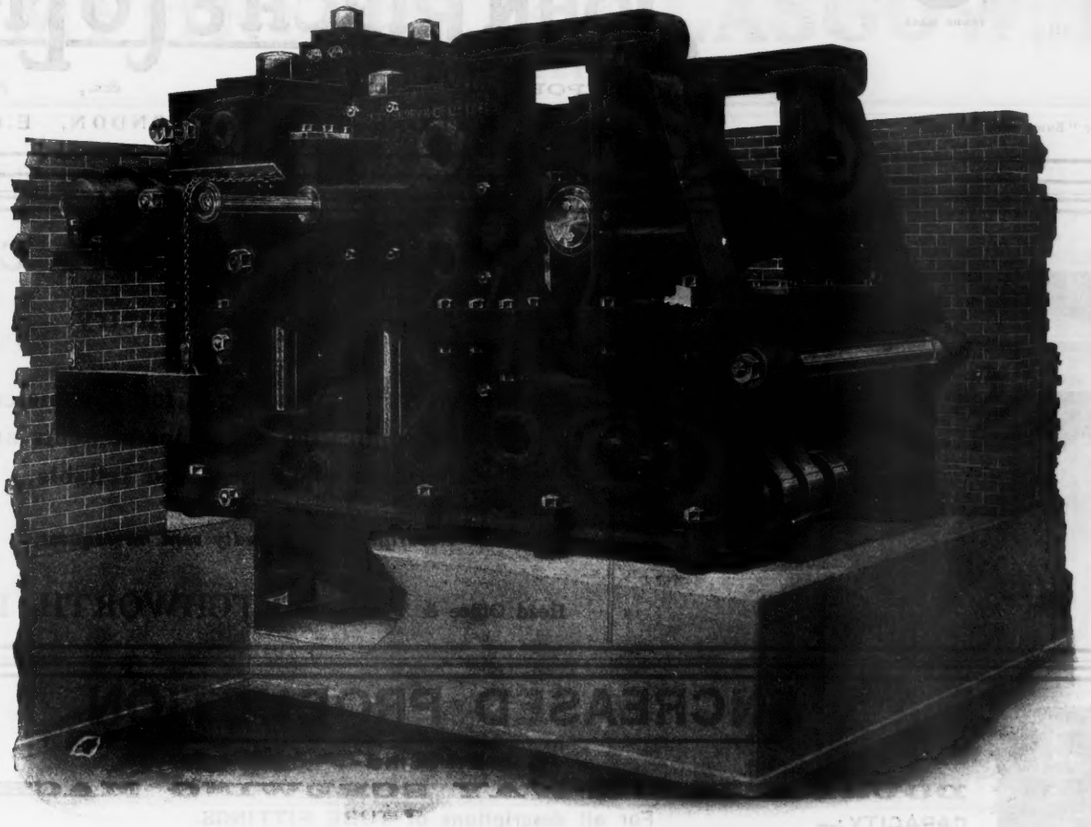

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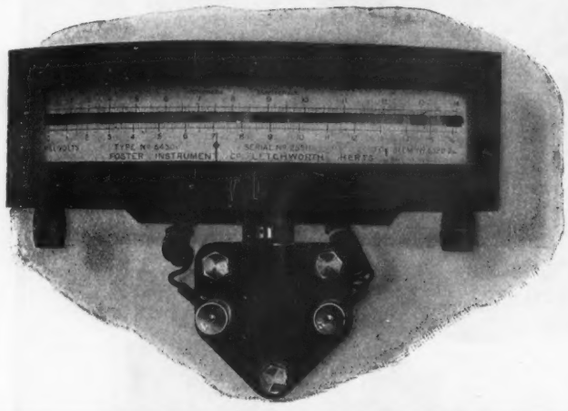

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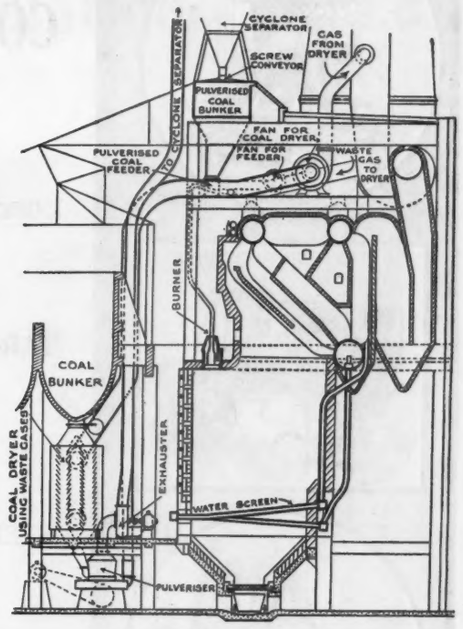

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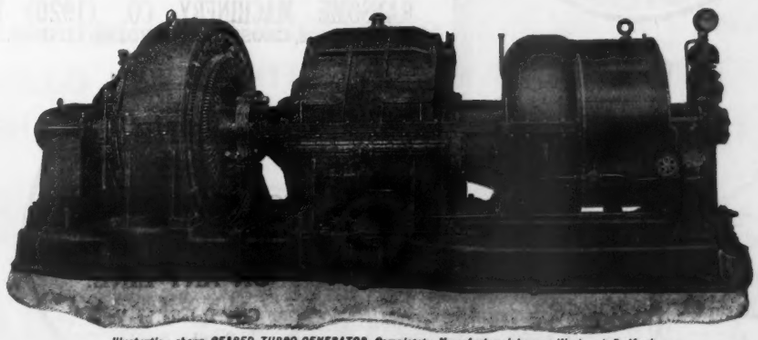

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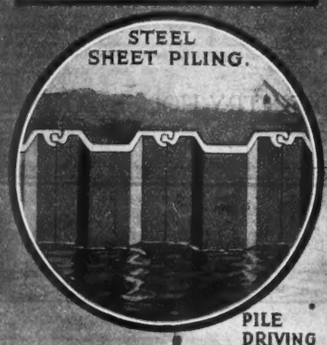

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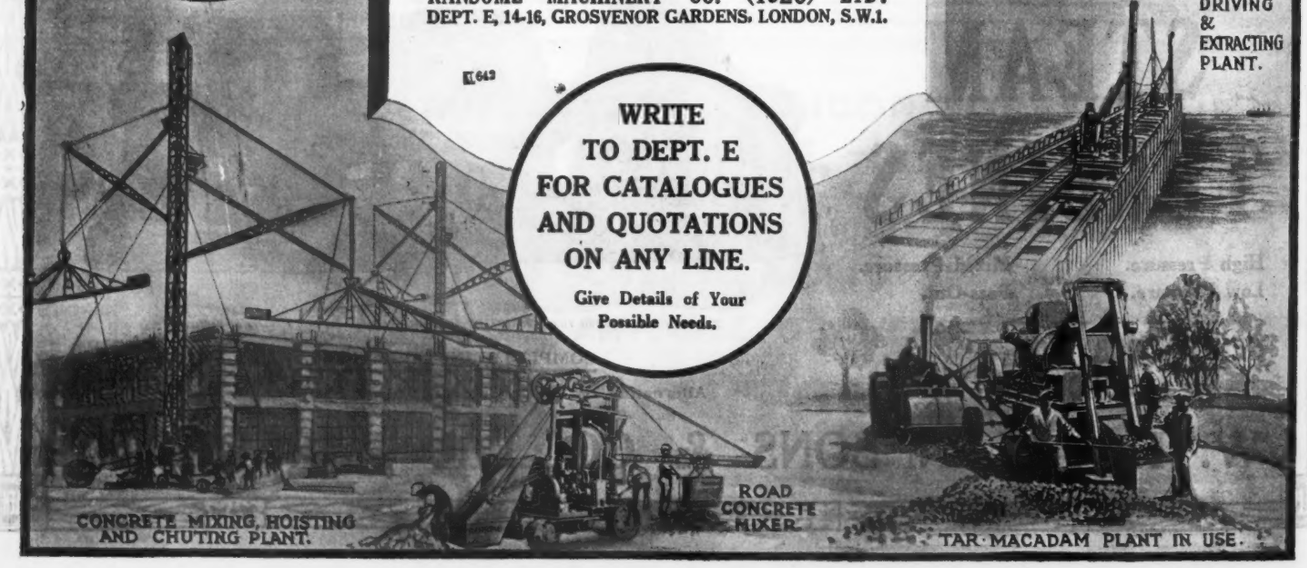

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FOR

LARGE ROUGHING AND FINISHING MILLS

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This Manipulator is the most efficient device for handling all sections at Roughing and Finishing Rolls, being:—

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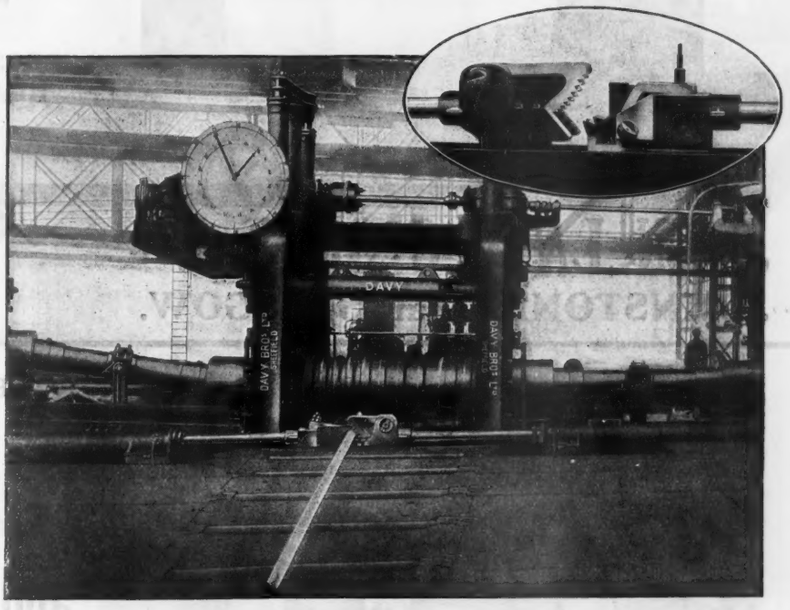

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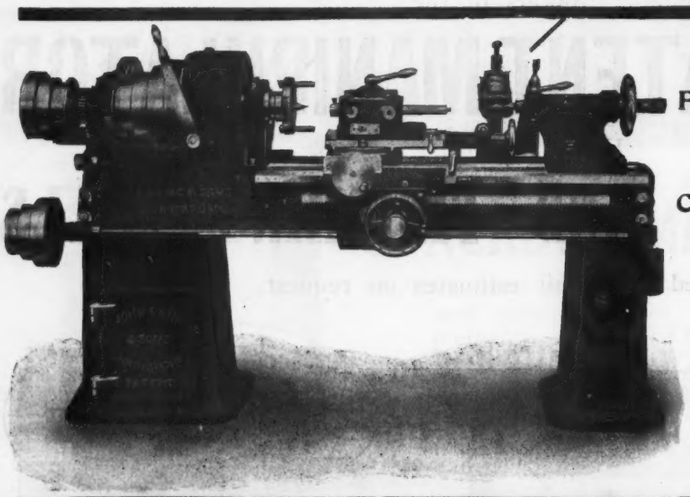

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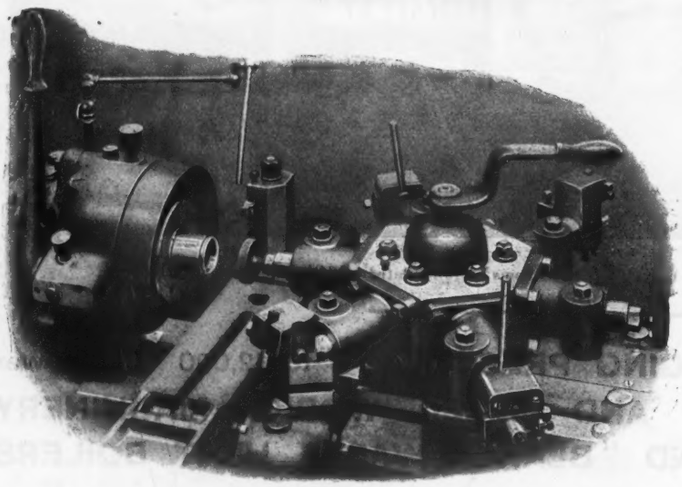

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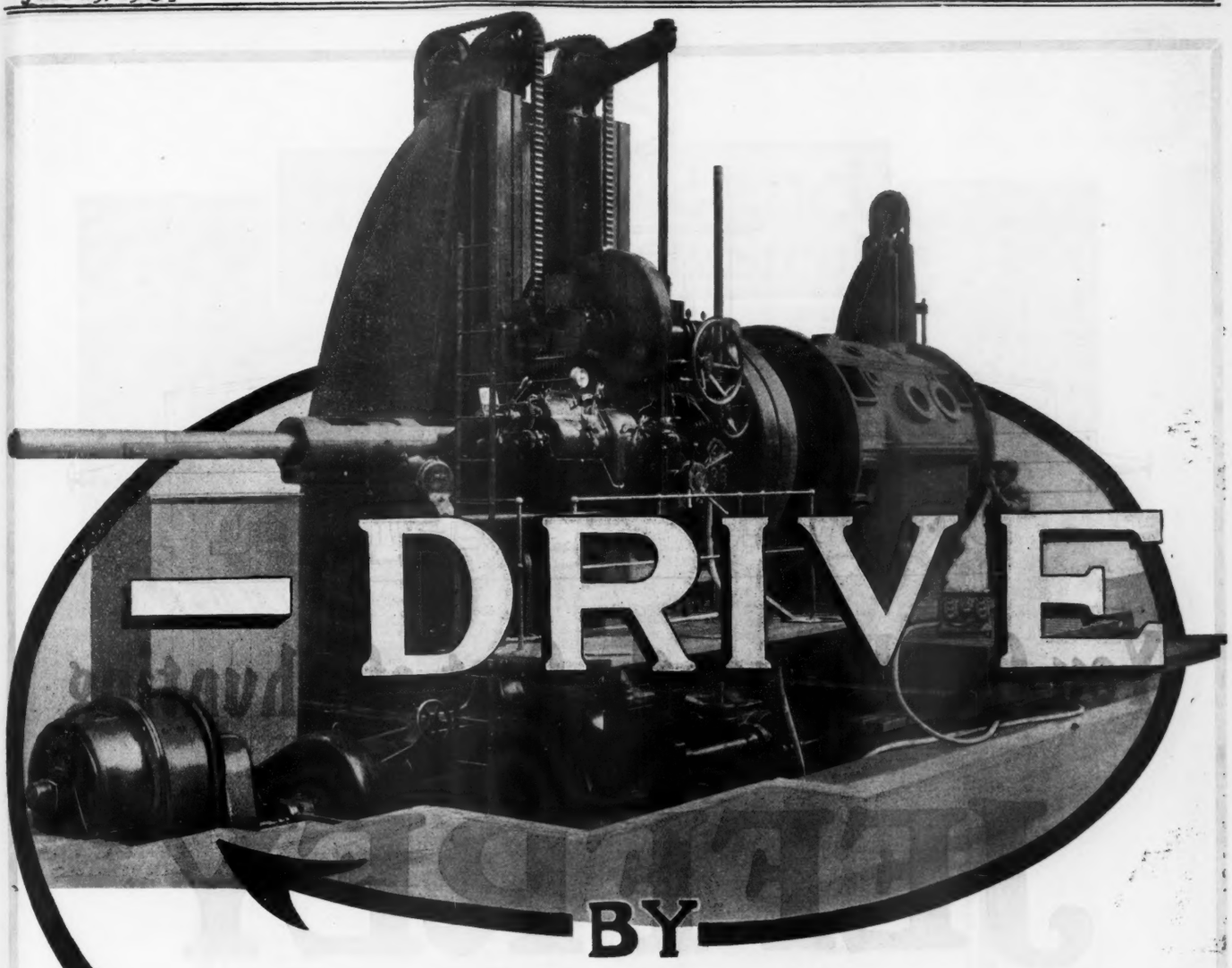

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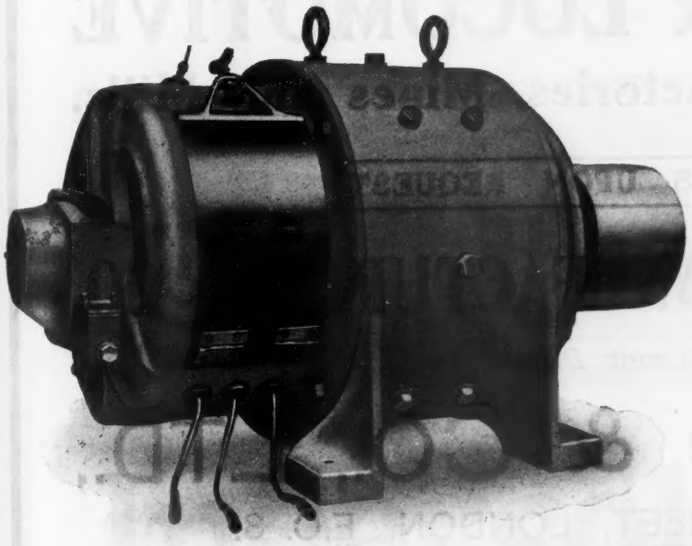

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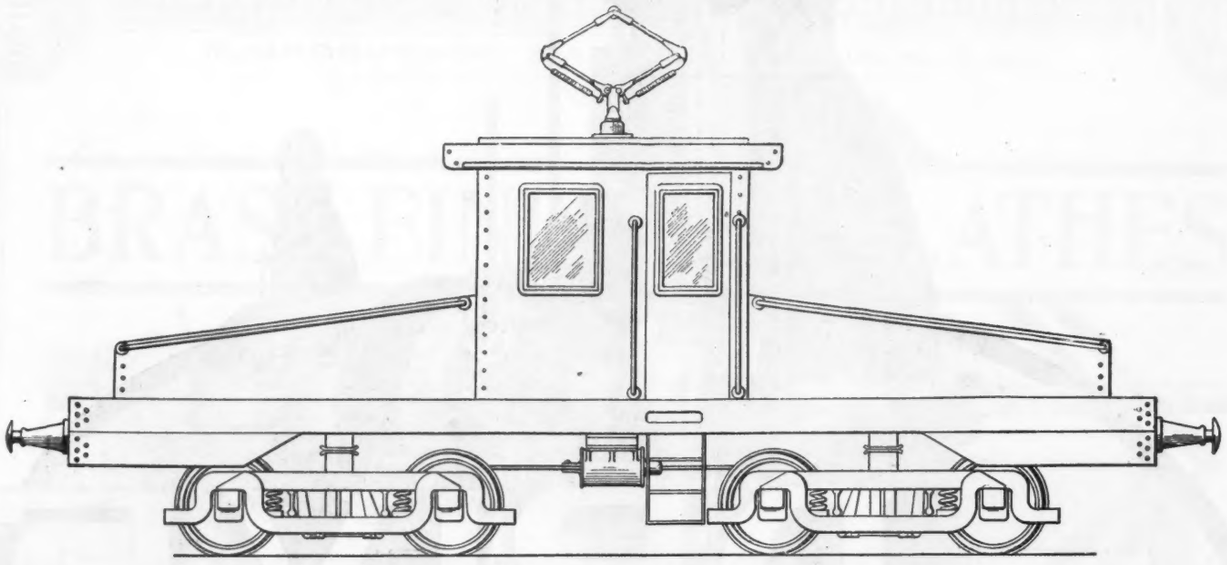

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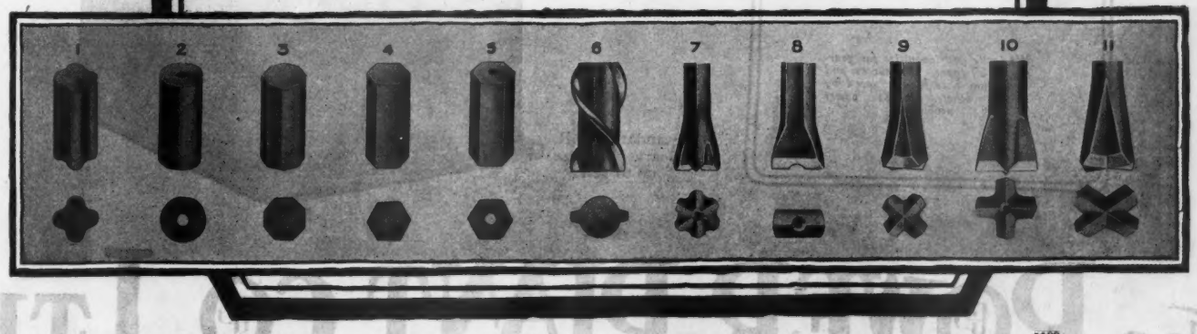

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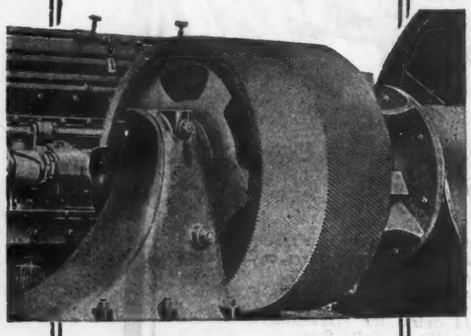

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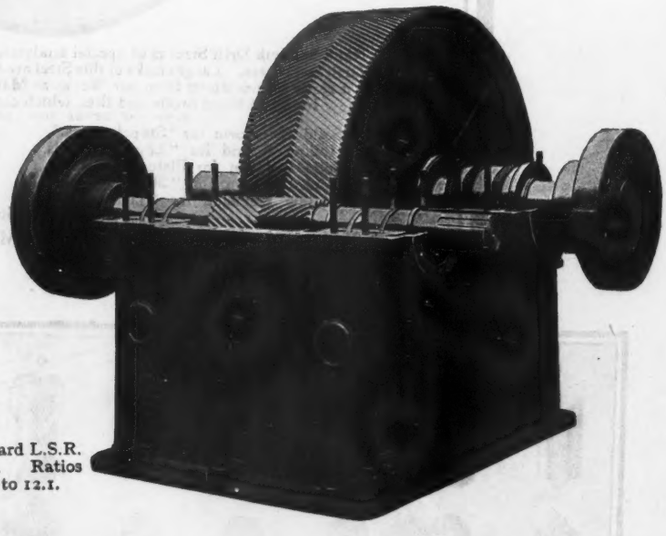

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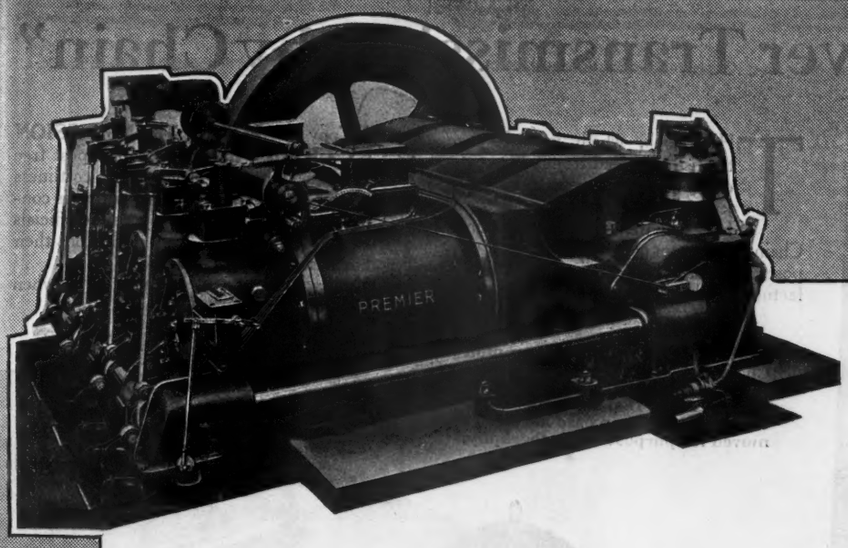

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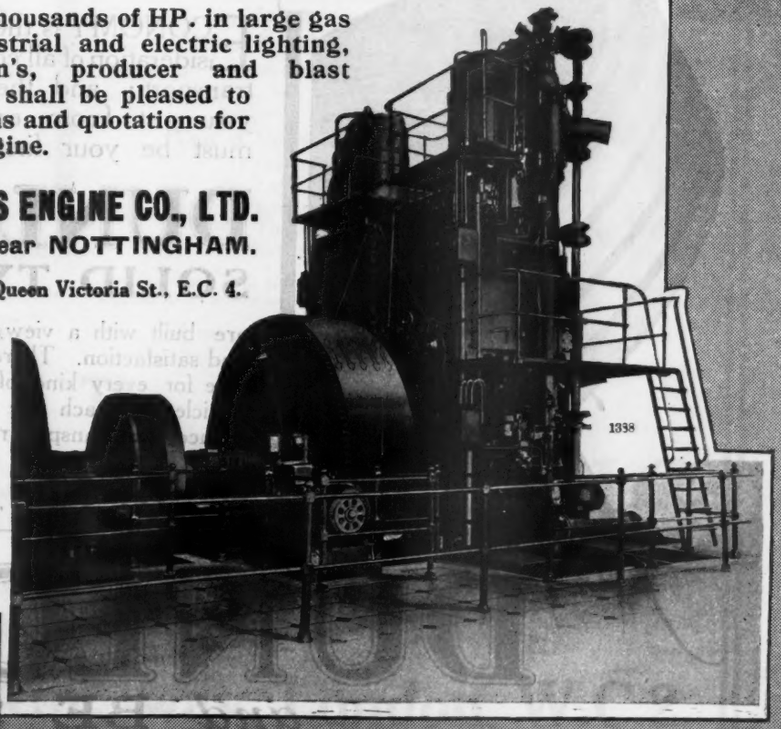
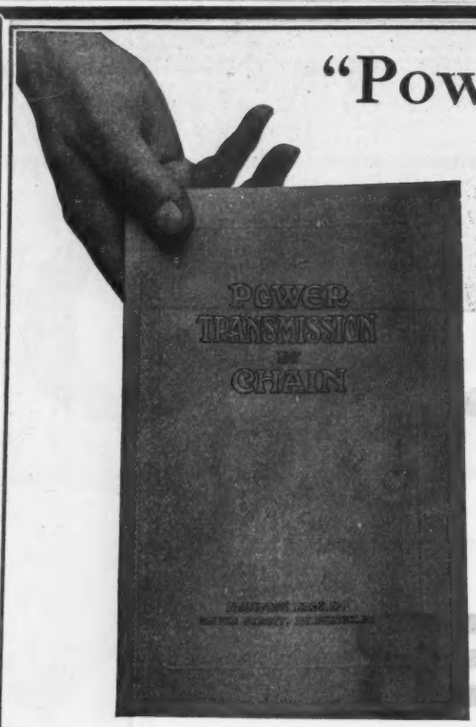


P. 3

"Power Transmission by Chain"



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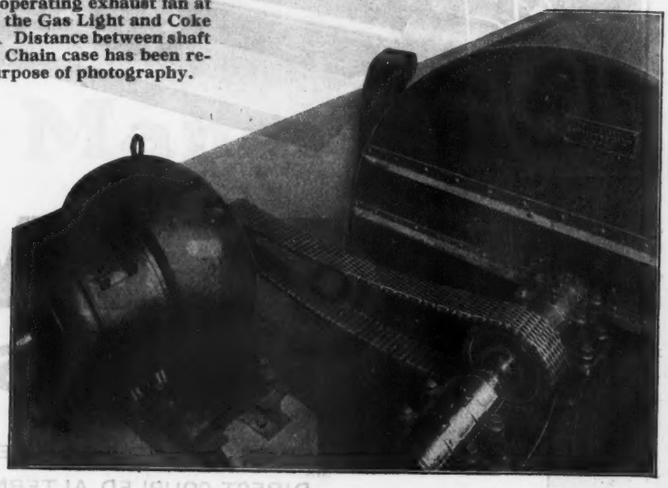
Illustrating a 20 HP. "Brampton" Chain Drive operating exhaust fan at the works of the Gas Light and Coke Co., Beckton. Distance between shaft centres 4 ft. Chain case has been removed for purpose of photography.



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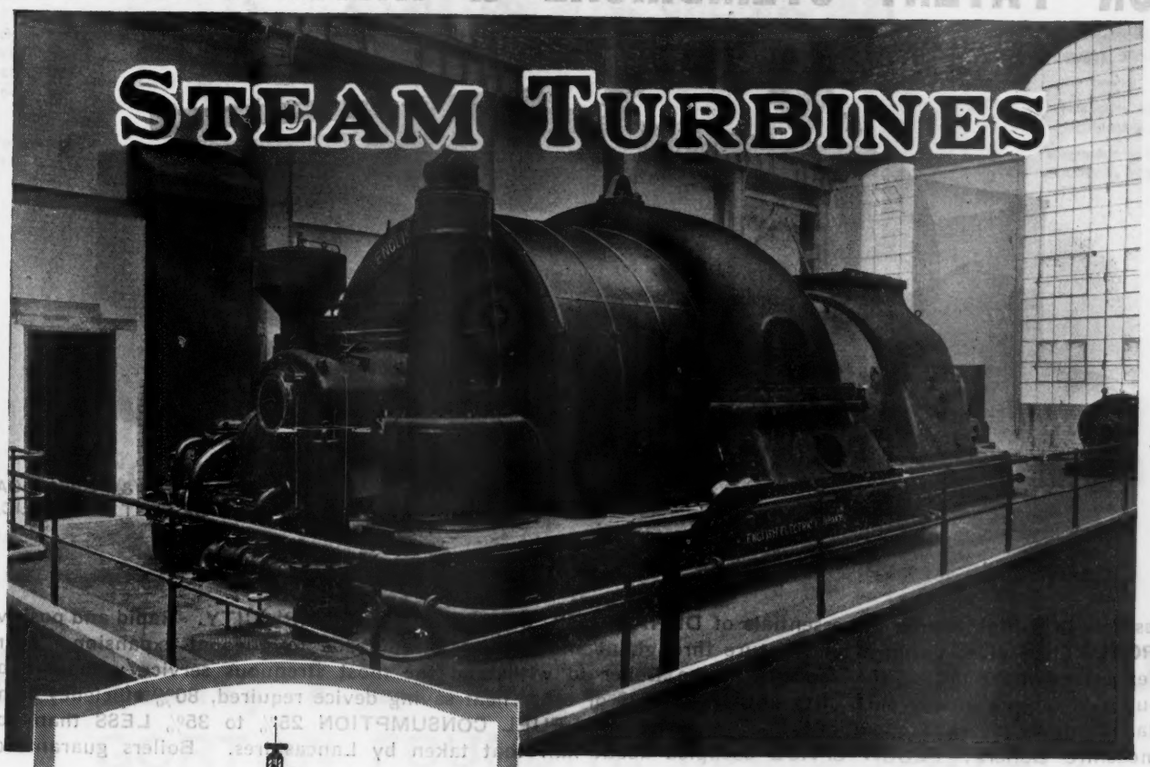

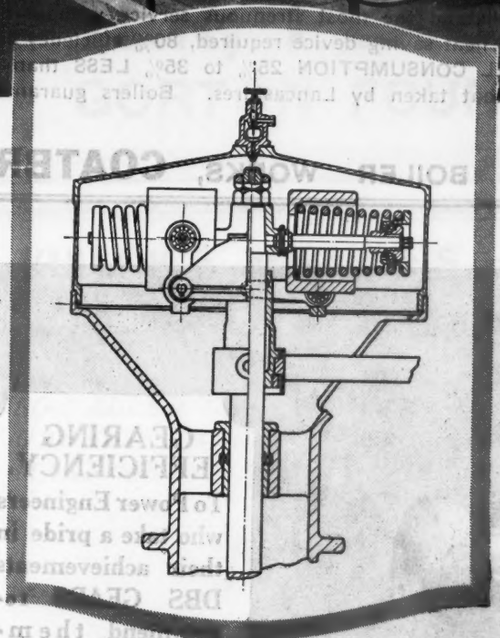

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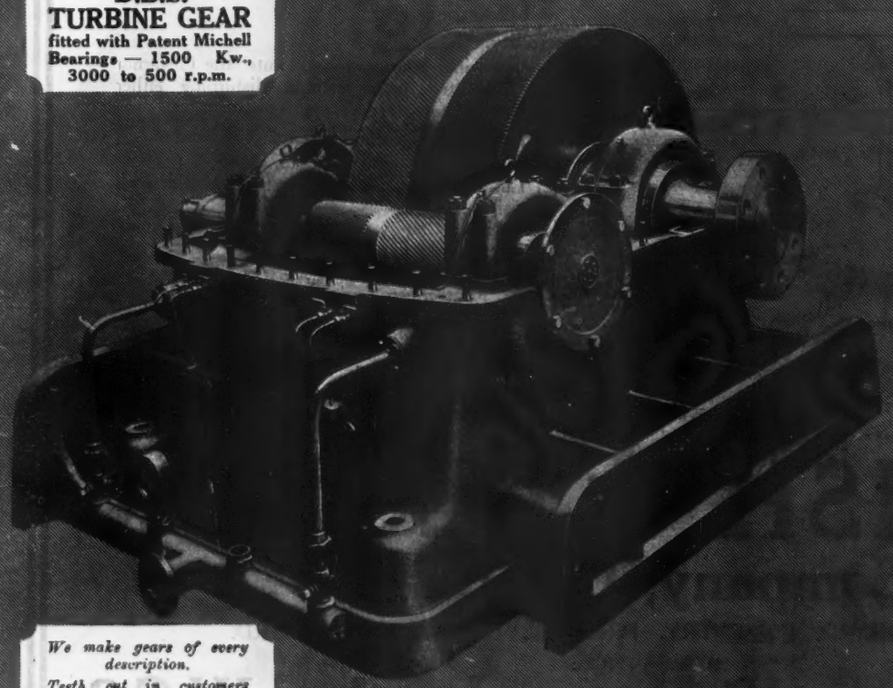

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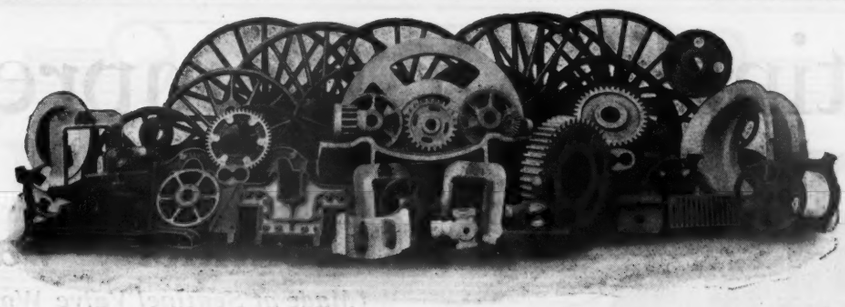

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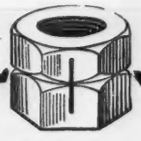

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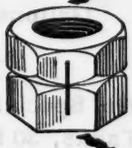

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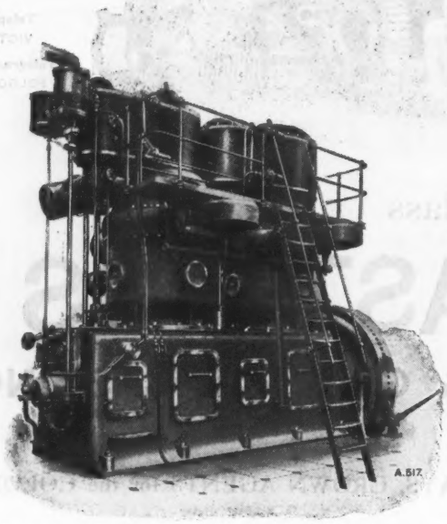

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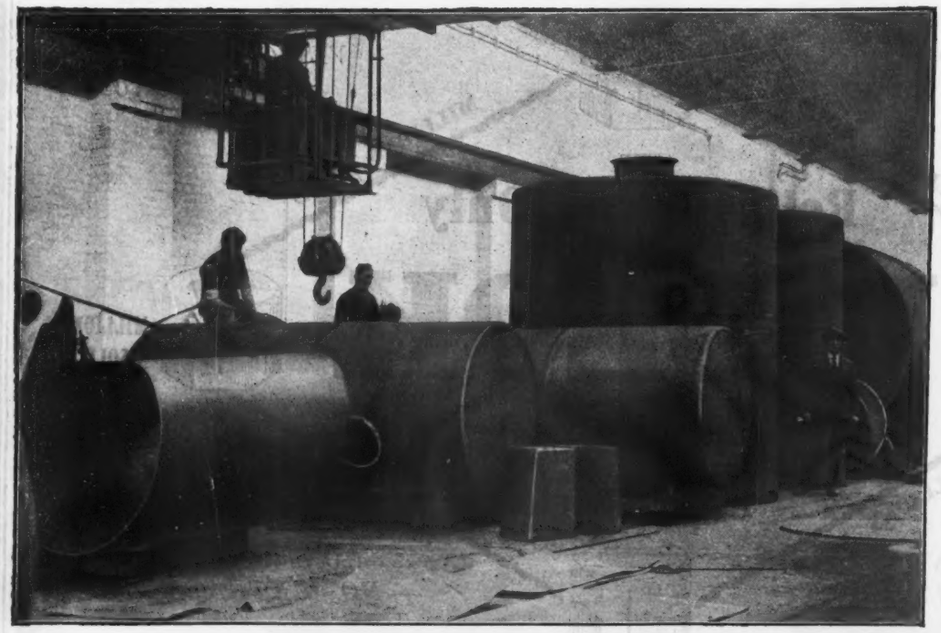

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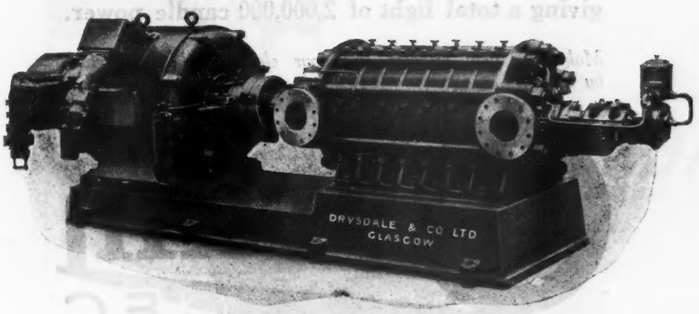

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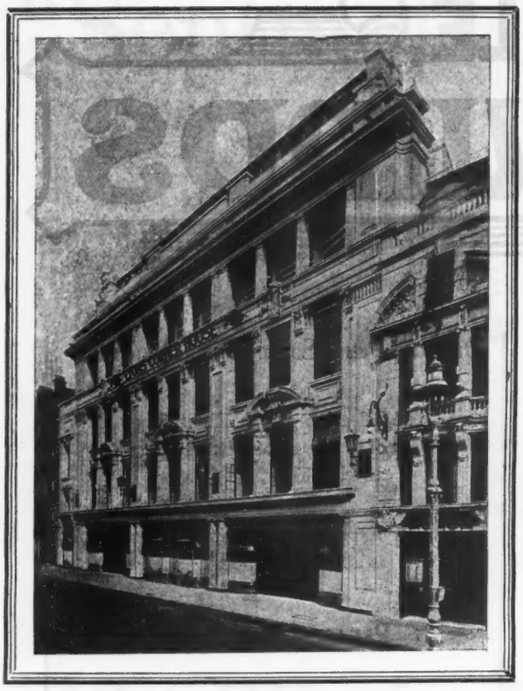

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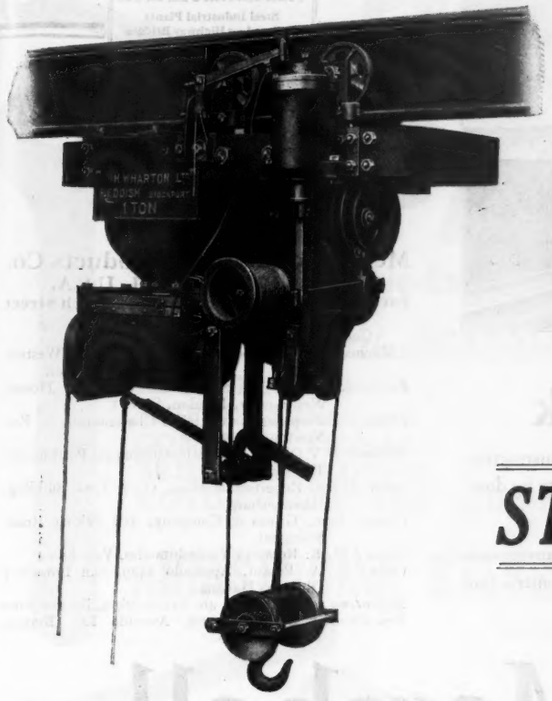

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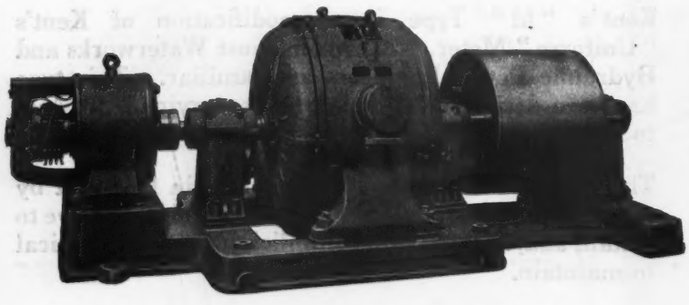

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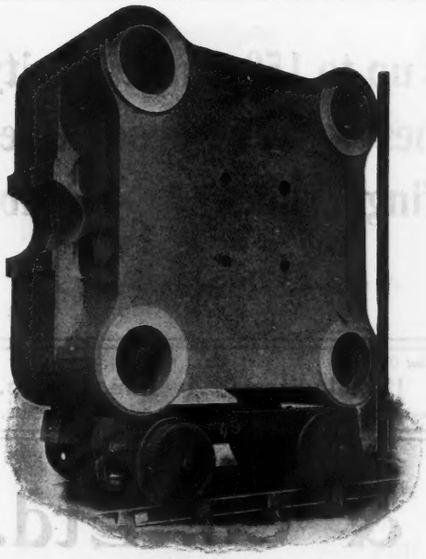

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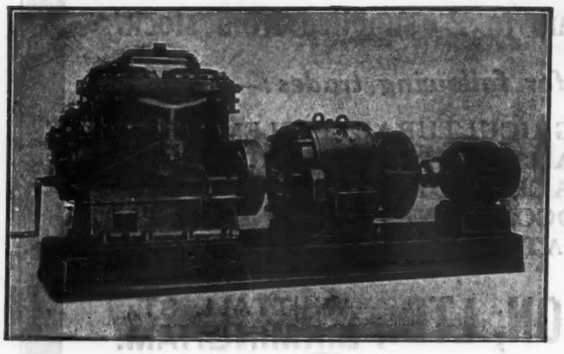

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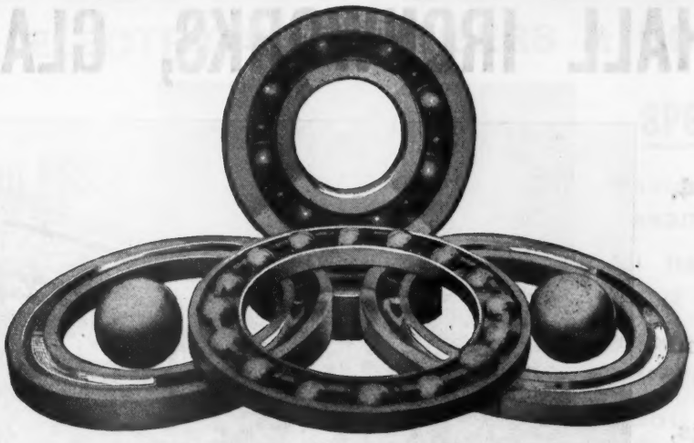

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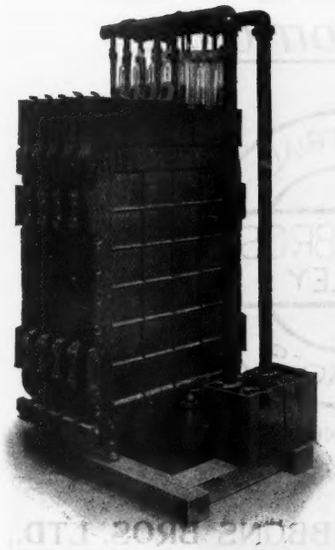

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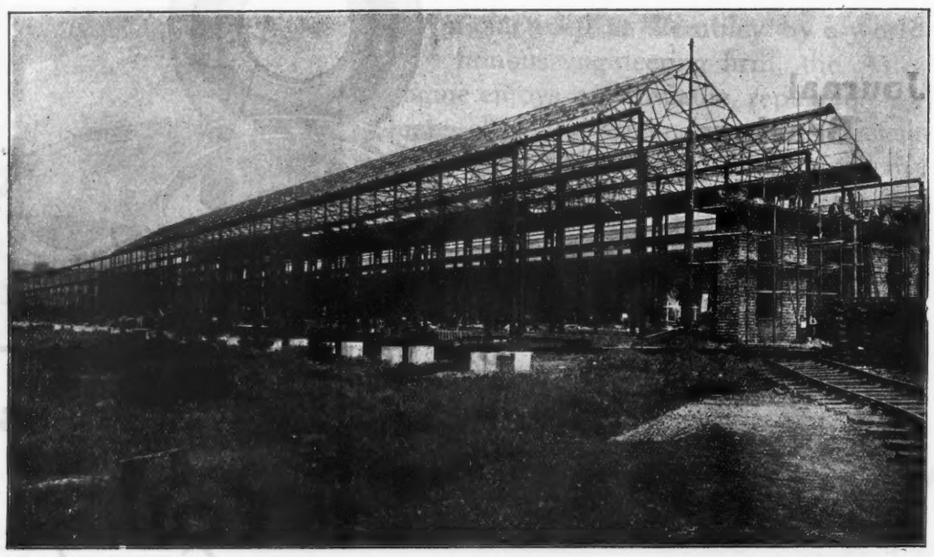

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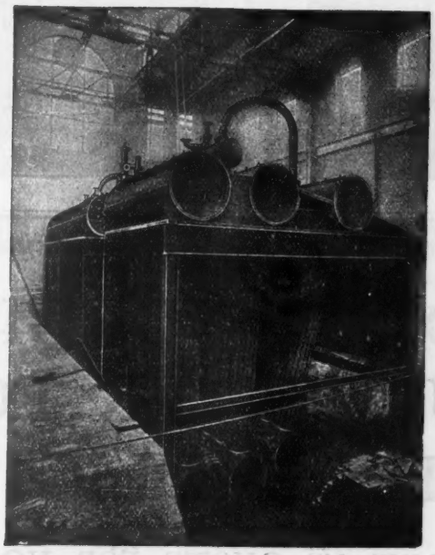

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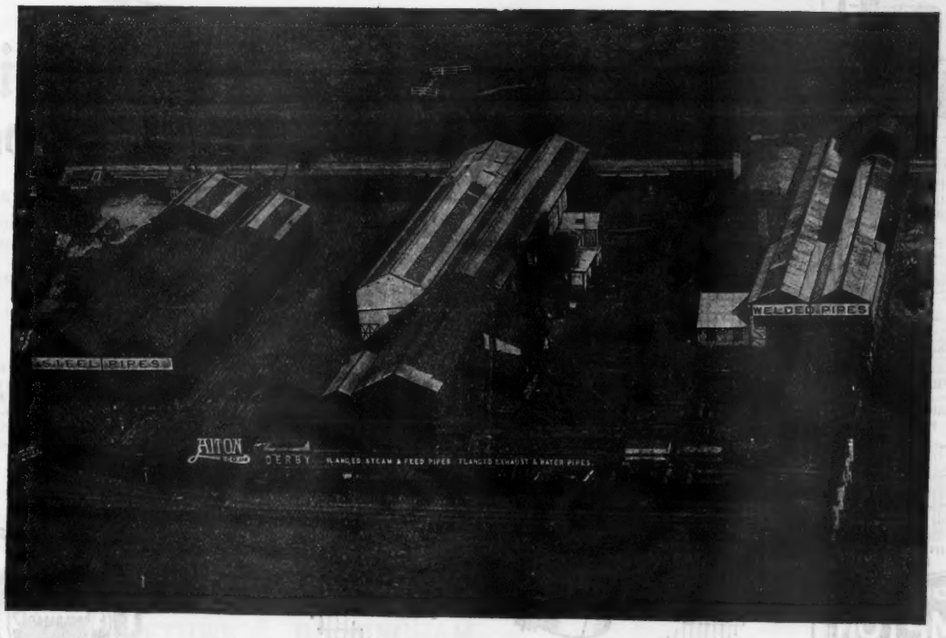

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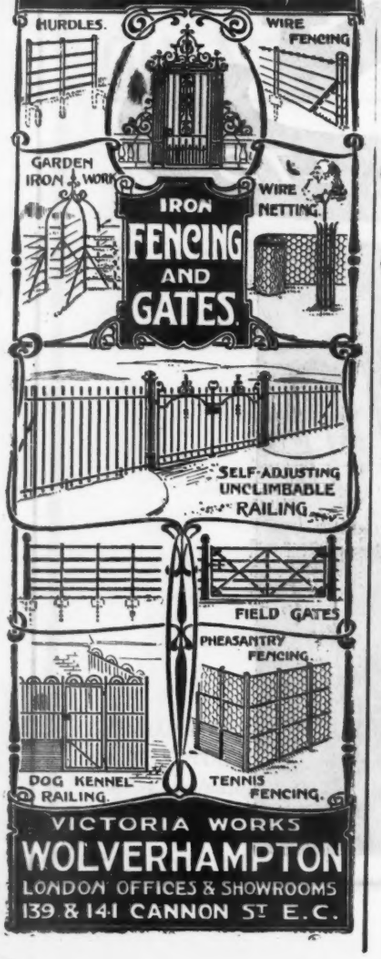

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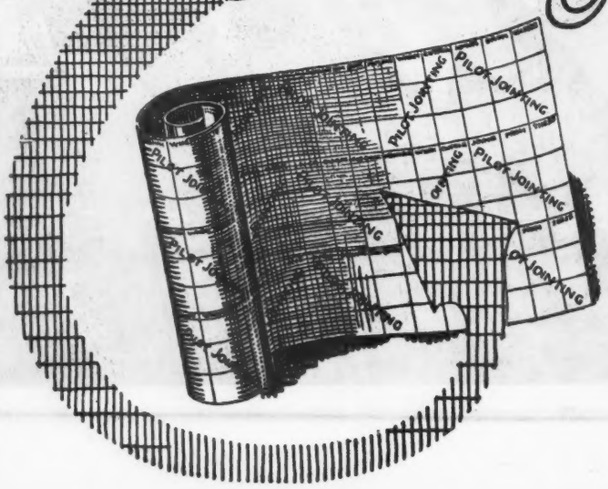

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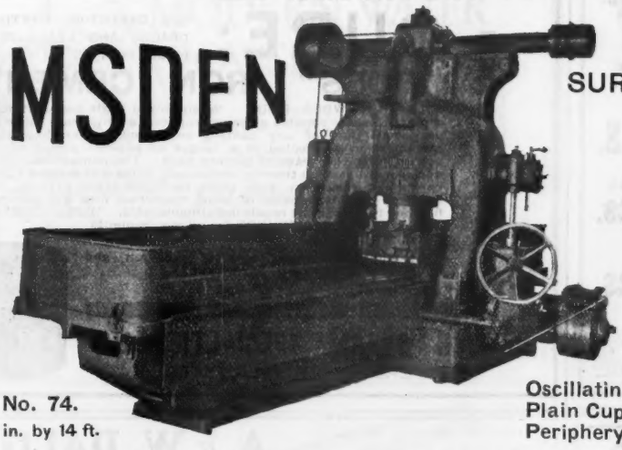

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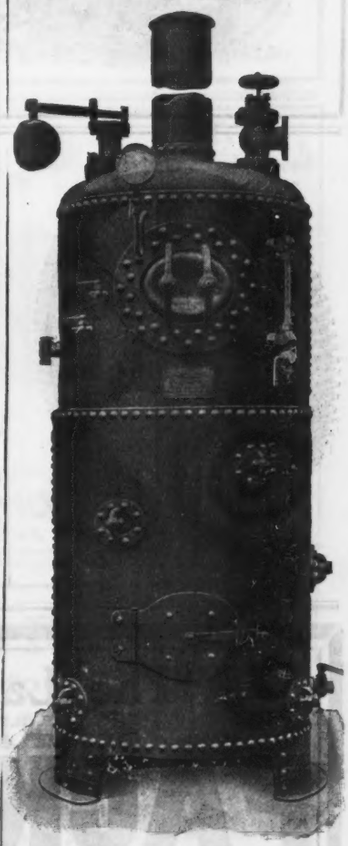

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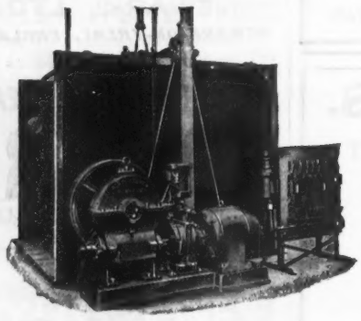

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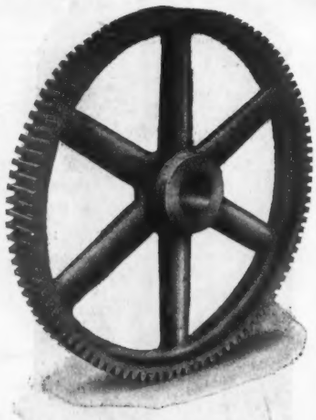

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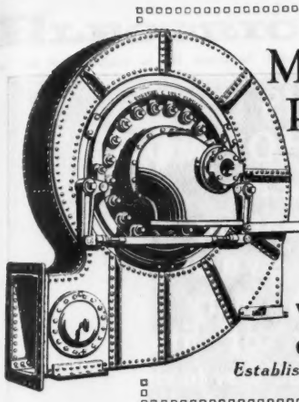

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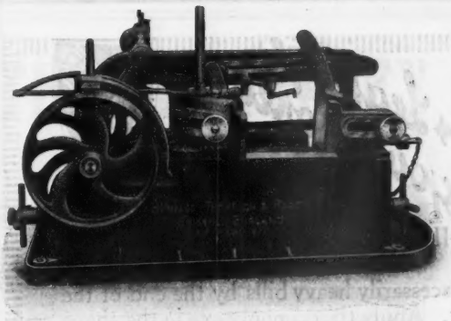

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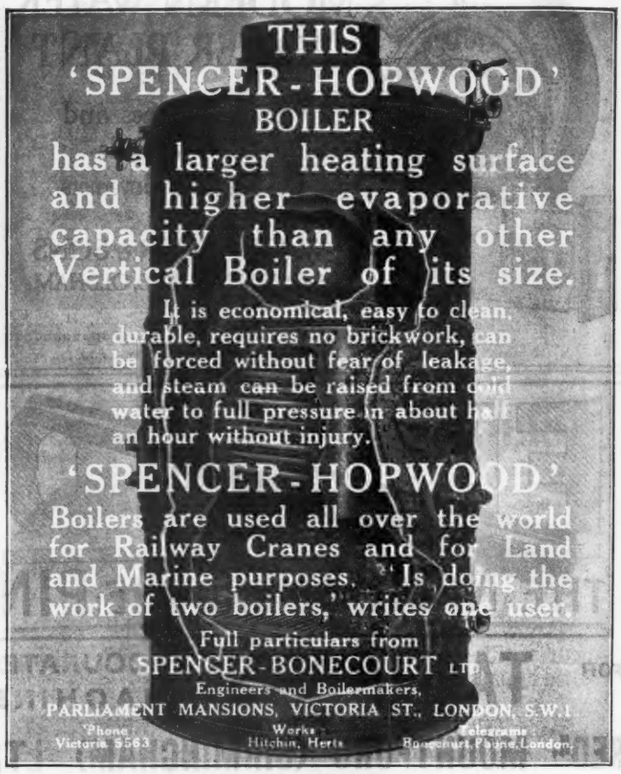
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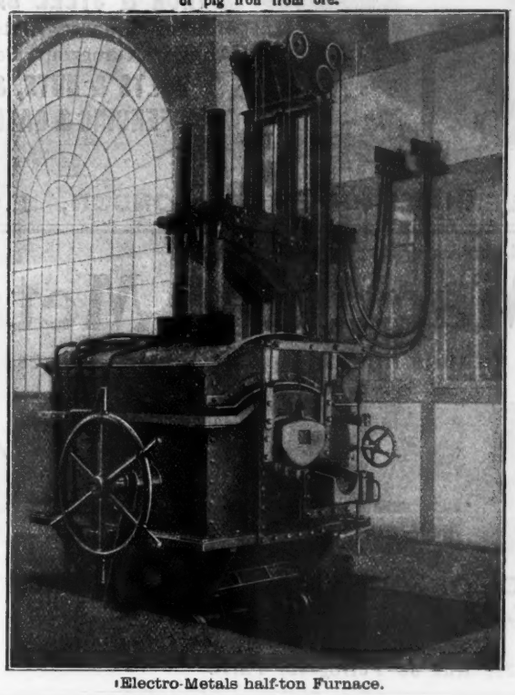

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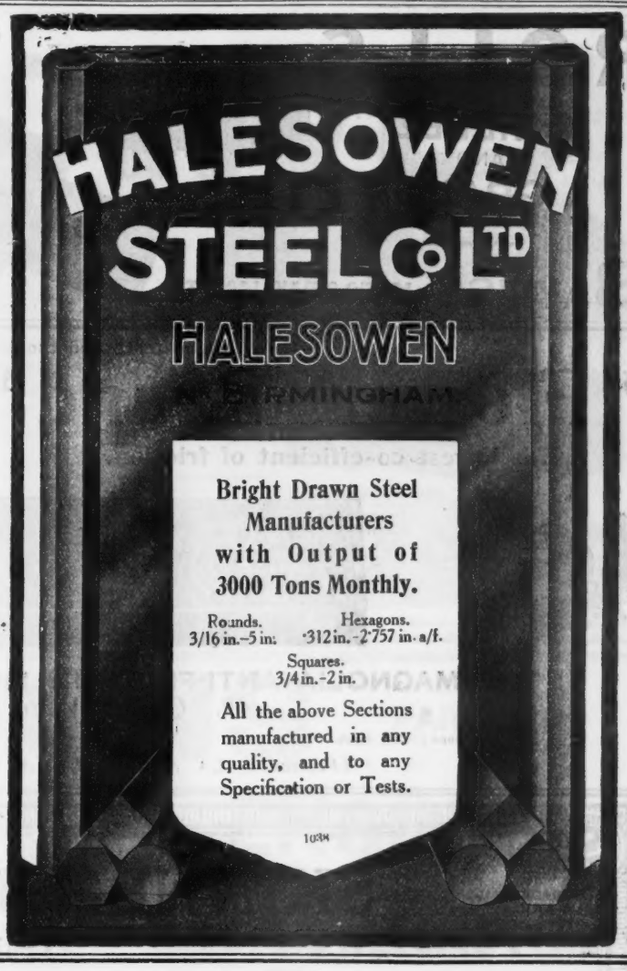

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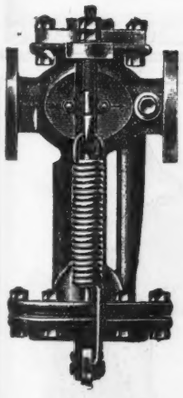

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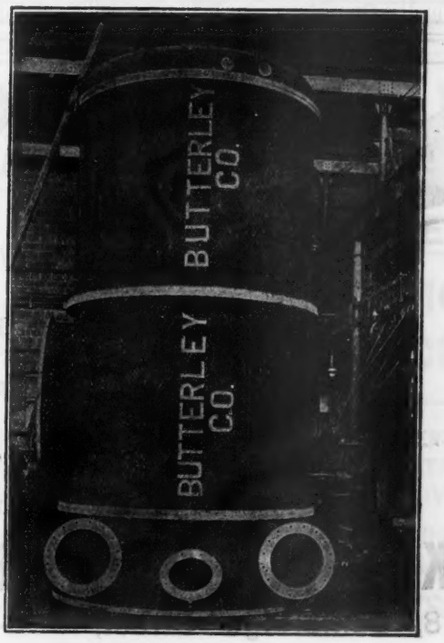

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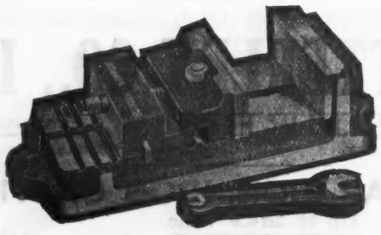

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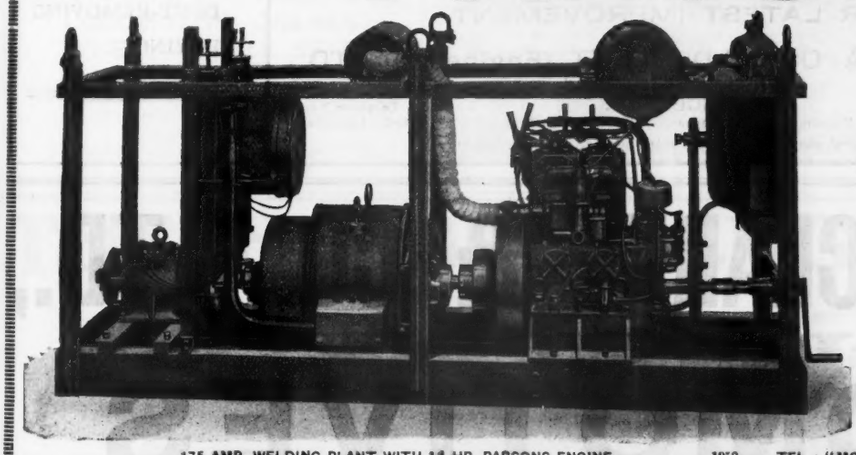

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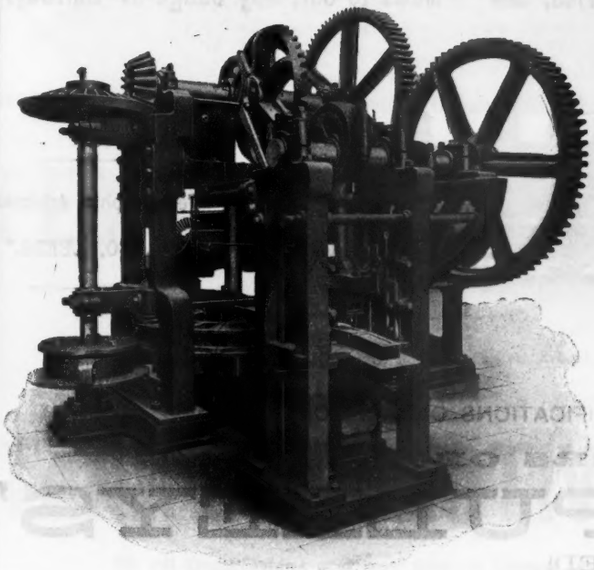

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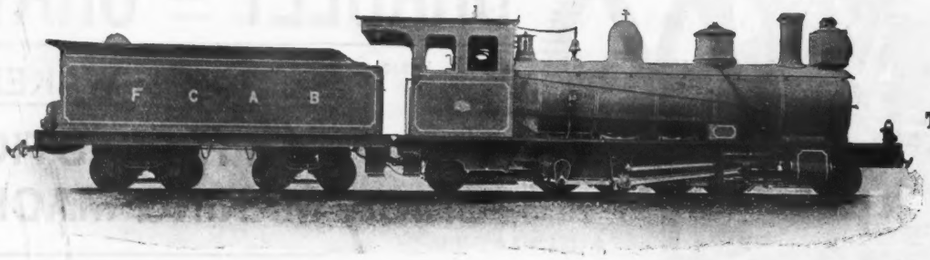

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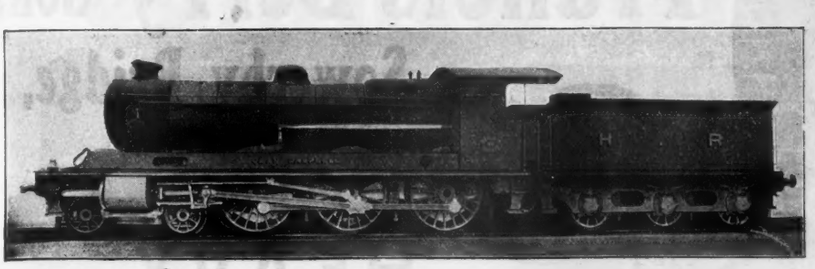

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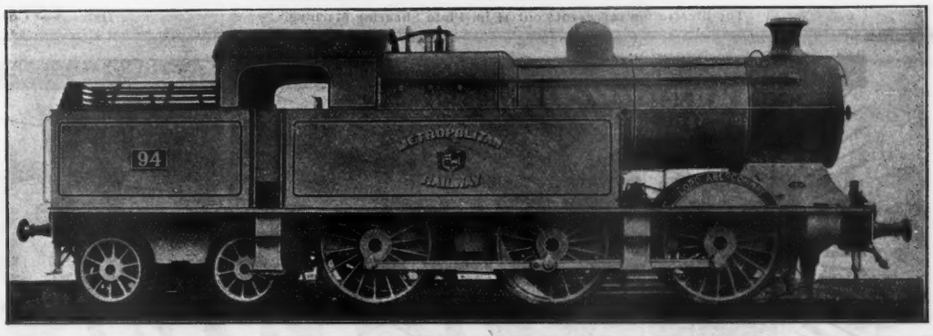

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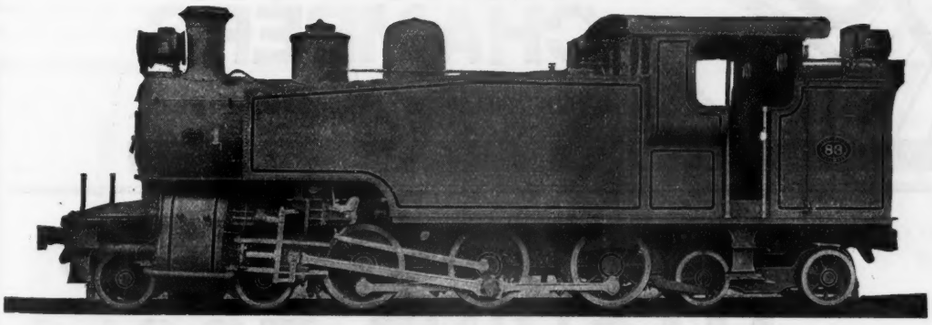

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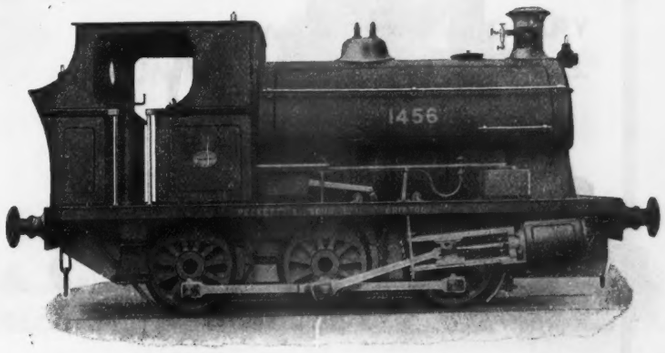

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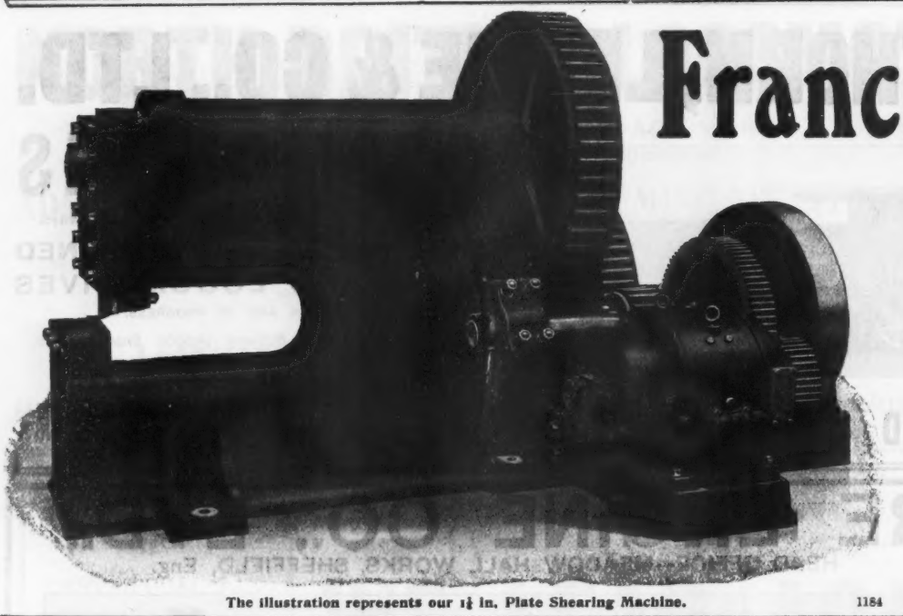

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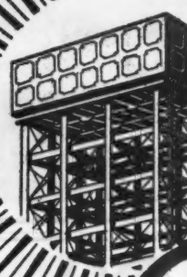

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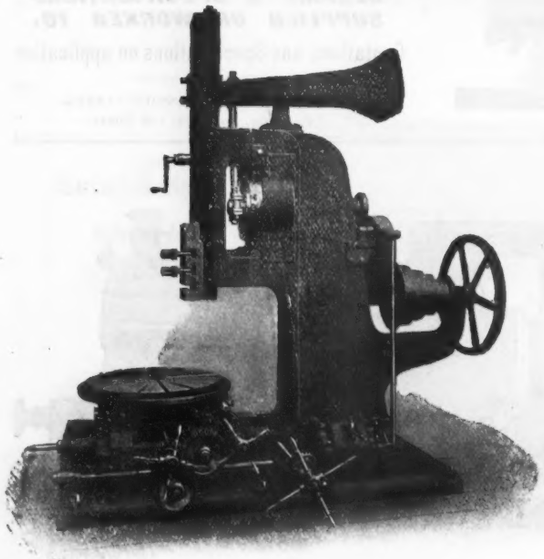

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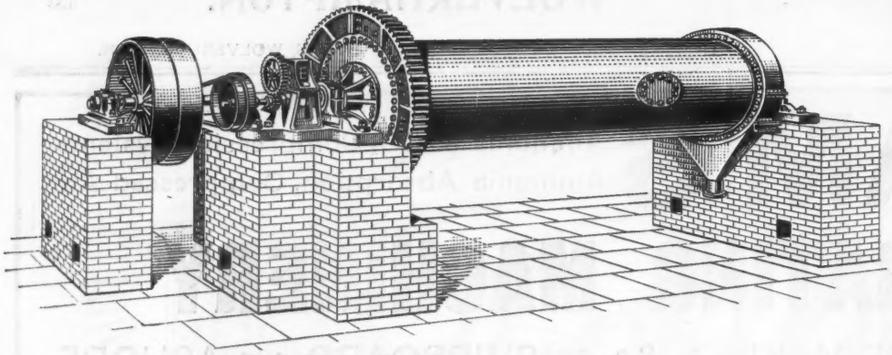

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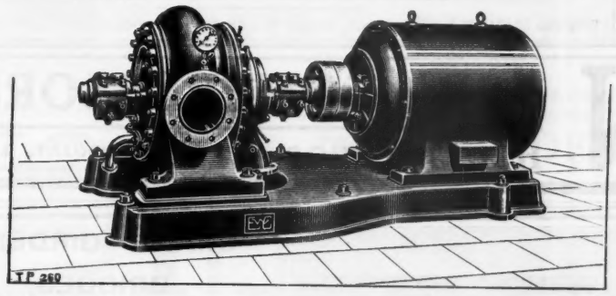

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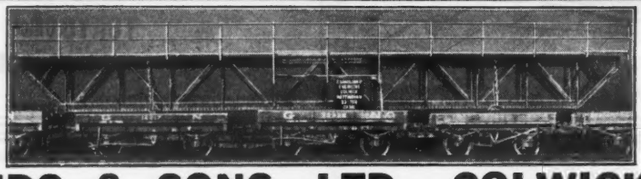

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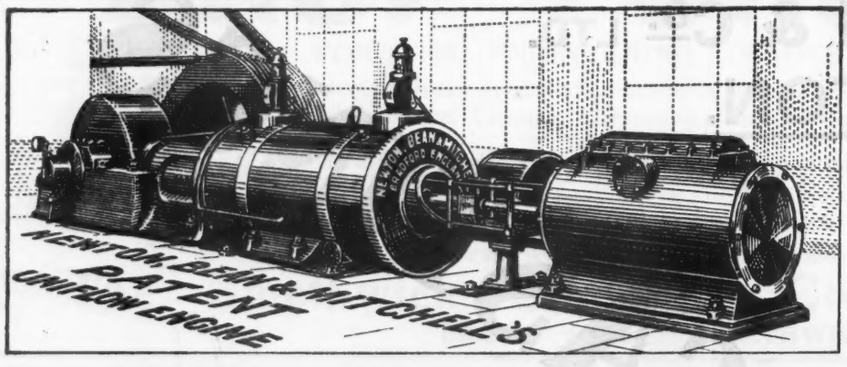

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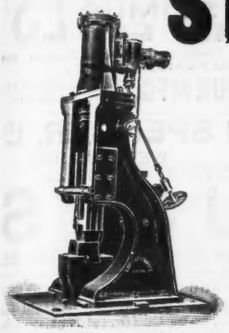

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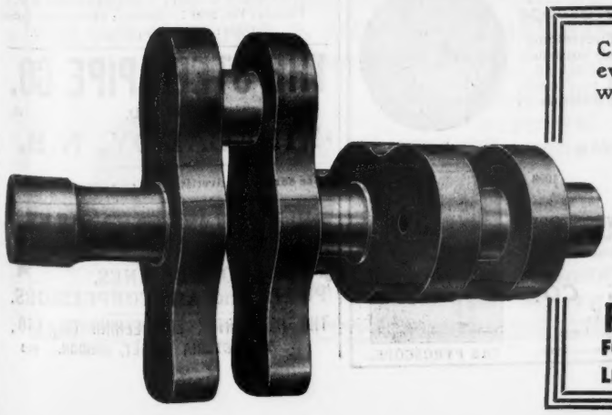

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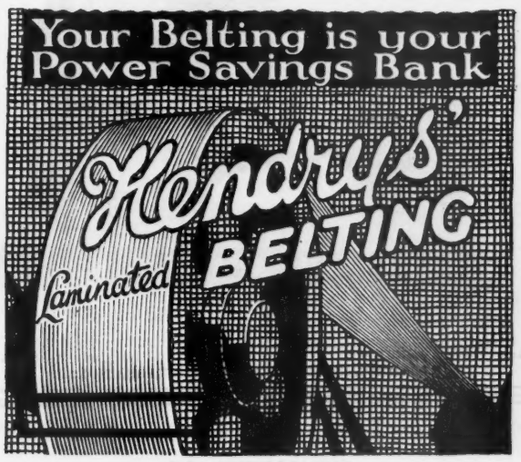

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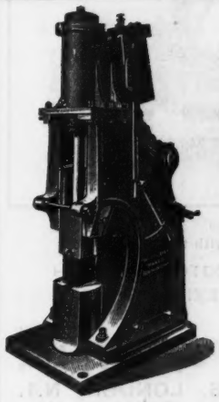

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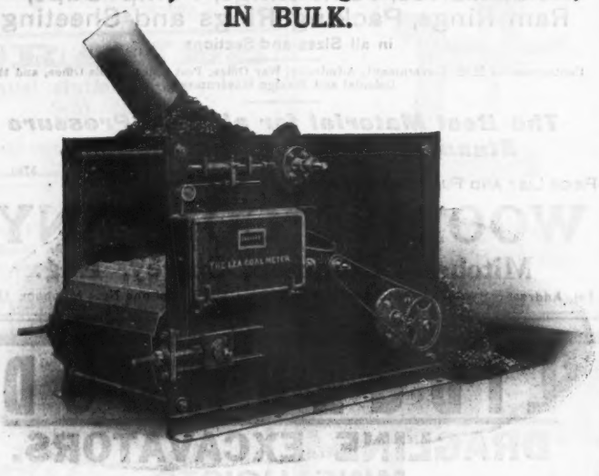

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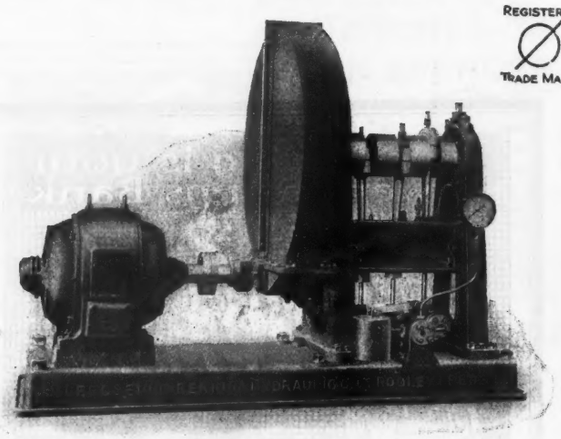

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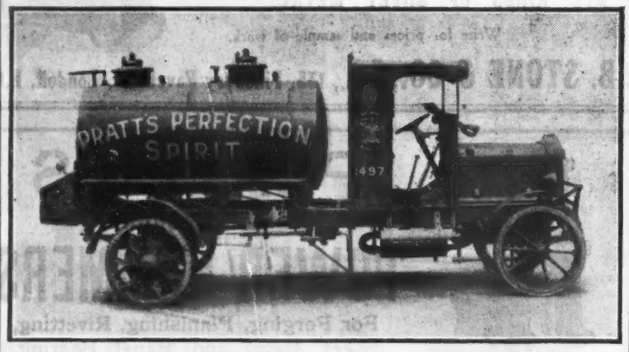

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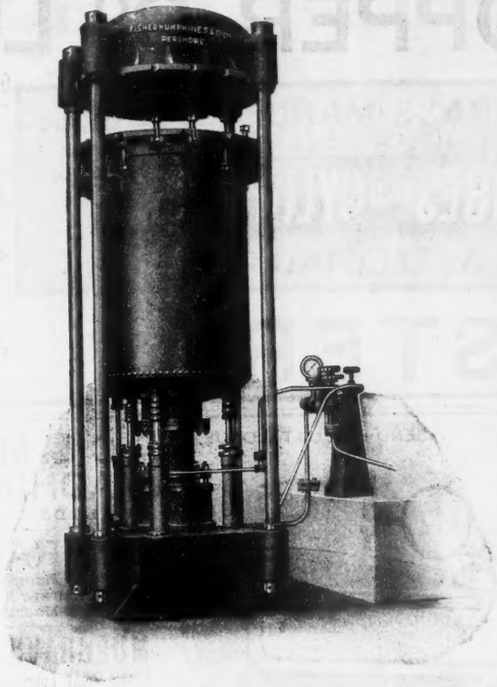

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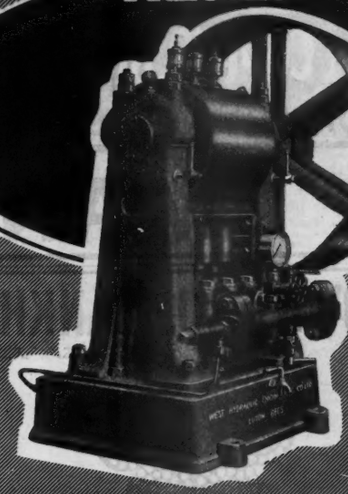

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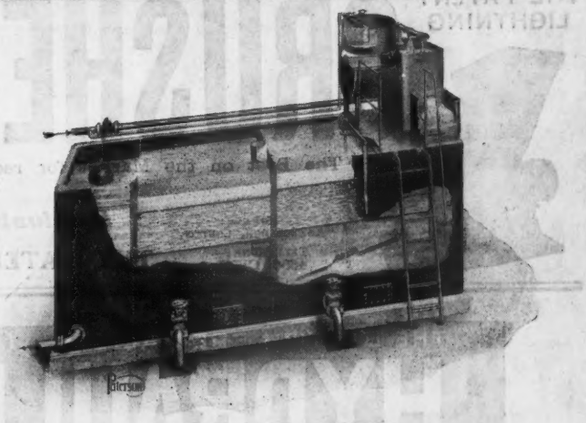

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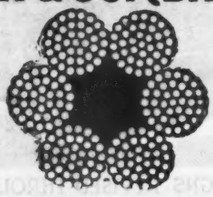

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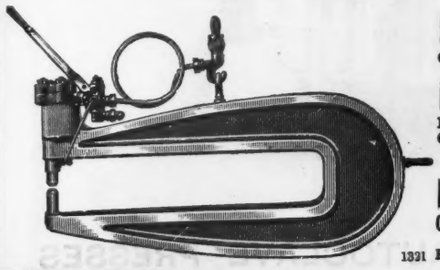

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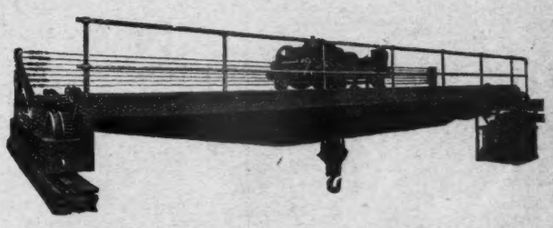
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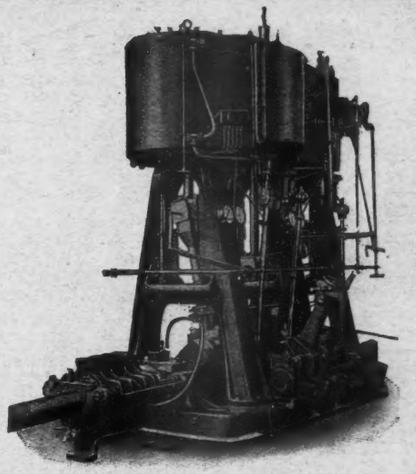
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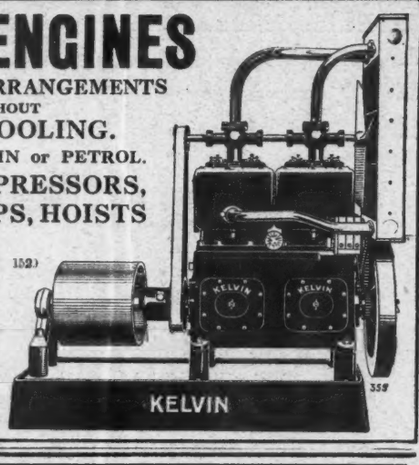

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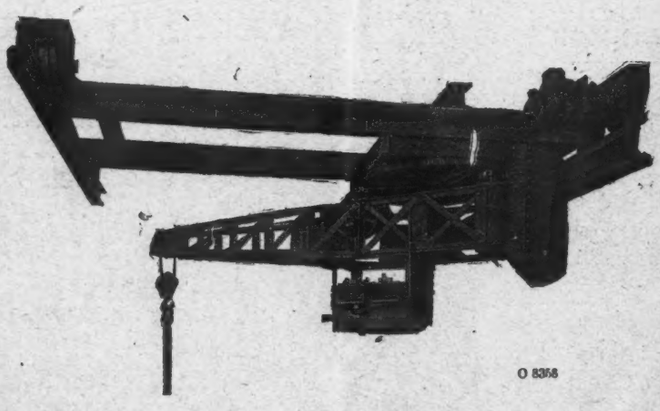
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